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### The Terminal Lake Canal.

BY LINDON W. BATES.

Much prominence has been given to the Minority Report of five members dissenting from the sea-level proposition in favor of an eighty-five-foot canal. It has not been so generally noted that the Terminal Lake Canal, with a summit level of sixty feet, was supported by a vote of nine to four in the Board of Consulting Engineers as the best lock type for the Panama Canal. The main features of this canal, which are very simple, may be shortly described.

On the Atlantic the canal cut begins near the head of Limon Bay. A low dam at Gatun, or preferably at Mindi, impounds Lake Chagres at a level of about thirty feet, entered by the first lock. This lake submerges the terminal swamps adjoining the canal and gives free open sailing as far as the second dam and lock, which makes the summit level lake at an elevation of sixty feet. At Gamboa, where the Chagres meets the canal, a

sluice dam guards the canal from floods. The regulated flow of the river enters the canal and is divided, part going to the Atlantic and part of the Pacific. This is the system accepted likewise for the Board's Sea-level plan. At Pedro Miguel the third lock marking the Pacific end of the summit level lowers the vessel into Terminal Lake Panama at twenty-six feet level. The fourth lock in the Acon-Sosa saddle lowers the ship into the Pacific.

This sixty-foot-level canal warrants attention, not alone from its endorsement by the nine eminent engineers whose votes were cast for it as the best lock canal, but because of its conformity to three principles which amount to engineering axioms, each of which the higher lock canal of the Minority violates.

The first of these relates to dimensions—with the growth of ship sizes, the maximum usable dimensions of locks should be 1000′ by 100′ by 40′, and there should be room at lock sites for even greater dimensions. The canon of lock dimensions is violater by the minority in that their locks as planned are of but 900 by 90 feet usable dimensions. The locks designed and adopted for the latest of Europe's national undertakings of this nature,—the Grand Coupure of Antwerp,—will take a vessel 984 feet long. The lock dimensions voted in the Board of Consulting Engineers by 11 to 2 before the division as to type took place, were 1000′ by 100′ of usable length. The length of 900 feet is too meagre a limitation to put on the size of vessels passing through the canal.

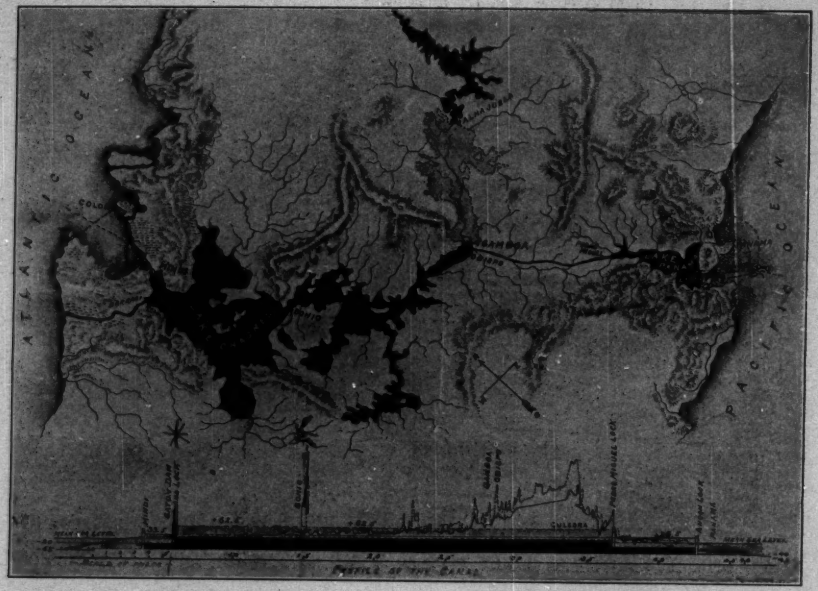
Still more significant is the inability to lengthen these locks to the full 1000 feet and have these vital structures founded in solid strata. The Gatun Hill is too low and too narrow for longer locks to be founded in rock. Their sides would project from forty to sixty feet above the rock line and would have to be built up to, with massive concrete structures. The whole flight instead of being securely buried in the rock, would be perched on the hill like three great boxes propped by concrete buttresses.

The sixty-foot canal obeys the canon of lock dimensions and lock foundation. The lock at Mindi, that at Gatun (or Bohio), the third at Pedro Miguel and the fourth at the Ancon-Sosa saddle are all of full 1000 feet length and founded in solid strata.

A second axiom is:—the hazards of over-running lock gates should eliminate from consideration the arrangement of locks in flight, one above the other. The experience of the Manchester Canal gives some idea of how fatal a defect is this scheme of locks in flight. No less than three times has a vessel crashed through its locks—with relatively small damage because the difference in levels was but eight to nine feet. The Minority violates the canon against lock flights in their three at Gatun and their two at Sosa. By the law of averages it is certain that at some time sooner or later a signal will be mistaken, an engineer pull the wrong lever, or the steering gear break at a critical time and an accident happen to a lock gate. Should this occur at an upper gate where the vessel starts to go down the ladder of three locks, the result would be inevitable and appalling. The enormous momentum of a great ship, with the mass of 40,000 tons of steel and cargo, could, though going at greatly reduced speed, crush the massive gates like matchwood, as the French liner went through the North River pier not long ago. The current would sweep the vessel over the lower gates and a released lake eighty-five feet high would pour out through the lock opening, wiping out like an avalanche everything below and making a loss to the canal itself irreparable for years.

The sixty-foot lock canal has no locks in flight, all are separated. An accident would loose at most thirty feet of water, and this would go into a broad lake below to be discharged with a minimum of damage through a large number of safety sluices. Further, with locks far apart, there can be put a middle gate in the lock for use with all except the comparatively rare, very great ships. With this, two closed gates could always intervene between the upper and lower levels and these would be 300 to 400 feet apart.

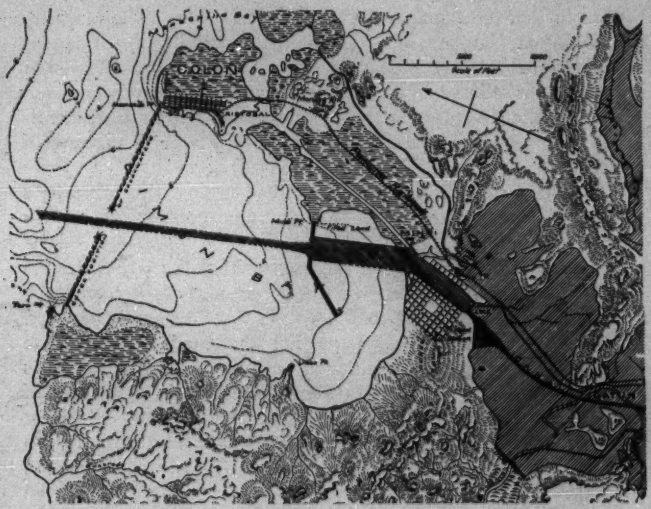
Finally there is the canon of the head of water to be allowed on impounding structures. Theoretically a dam can be built as high as one pleases if percolation is blanketed by a long enough backing to it. As a matter of actual practice there is a more or less well defined limit beyond which a conservative engineer does not go. On the alluvial foundations of the Isthmus no dam should be made with a greater head than forty feet to keep within the most assured limits of engineering security.




*The Terminal Lake Canal, summit level 60 feet.* Three navigable lakes, no dam with a head over 36 feet net head, locks widely separated, never in flight. Chagres regulation by empty basin system and Assuan type dams.

The minority's eighty-five-foot lake violates this by imposing a full eighty-five-foot head.

The sixty-foot plan keeps within the bounds of conservatism by making no head over thirty-six feet. The main dam has sixty feet of water in Lake Gatun-Bohio above and thirty feet in Lake Chagres below. The head producing percolation which is the difference in levels, is thus but thirty feet, which is absolutely safe and unquestionable.




*Balboa Harbor:* Proposed Terminal City of Balboa, having an Inner Fresh Water Harbor on Lake Chagres and an Outer Salt Harbor at the head of Limon Bay. The new sanitary city built on hill on American Territory, Colon on its marsh being abandoned.

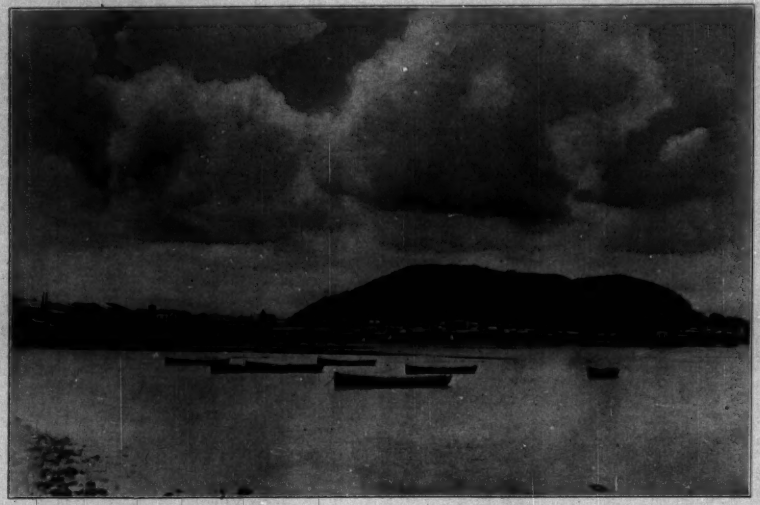
So significant are these deficiencies and inferiorities of the Minority's plans; its limitation of vessel size; its imposition of a monstrous and experimental dam; and its perilous arrangement of locks in flight, that the writer considers it rightfully eliminated as against the sixty-foot lock plan.

The superiority of the latter is in fundamentals and is inherent in the sixty-foot canal, either as originally proposed by the writer, or as modified by the Board in their final proposal.

As given forth by the Board, two sites are selected which were offered as second choice instead of first when the writer's Terminal Lake Canal was laid before them. Bohio is taken by the Majority as their site for a summit level dam and Gatun for the lower level, while the original plan preferred Gatun as the summit level site, because seventy-five per cent. more water flows past it, giving a greater lockage capacity, and Mindi as the lower dam site because it gives three more miles of lake navigation and submerges three more miles of swamps. One further item defines the latest official plan. The Majority propose at Gamboa one high dam impounding a permanent lake. The original plan was for a Gamboa dam of similar nature, but of less height, and a duplicate at Alhajuela, thus averaging the control over two low dams rather than concentrating it on one high dam. But these are obviously matters of detail only.

Having weighed the sixty-foot plan against the Minority's Gatun Dam Lock flight scheme, the final comparison is with the Sea-level.

Before, however, making the comparison, the writer desires to complete the description of the sixty-foot canal by including his unadopted provisions for terminal harbors. In none of the Board reports are full plans made for the future canal ports. Only at the Atlantic terminus were any proposals relative to them advanced. These consisted in five miles of breakwater at depths and on foundations undetermined, whose cost must vastly exceed the large estimate, and designed to make a port at swamp-founded Colon. There was submitted in the writer's project an inner harbor making a protected anchorage at the head of Limon Bay. It was proposed to abandon Colon with its miserable wooden shanties built on stilts over Manzanillo Marsh on Panama territory, and to establish a new city on American territory near the Mindi canal entrance. Here, where the first lock enters Lake Chagres can be built a sanitary terminal on a rocky hill. In front will be the salt harbor in the head of the bay. Behind it a clean fresh water lake submerging all the festering swamps under thirty feet of clear water. The inner fresh water harbor would be free from tide and current and would be sheltered from all storms and waves. Under the hill on the lake can be established a



*The Panama Bay Front:* It is proposed to reclaim the tidal flats with Culebra spoil, much of which would otherwise be wasted at sea. The hill is Ancon, behind which, on Lake Panama, could be made an impregnable naval station.

naval station which could not be reached by hostile cannon. This is the port of Balboa, which is proposed for the Atlantic terminus.

For Panama, breakwaters were designed, whose arms were to enclose the whole harbor and La Boca and to terminate at the rocky harbor islands. These breakwaters would encircle and create the safest, largest and best harbor of the South Pacific, with scarcely more cost than would be required to get rid of the material by wasting it at sea. Within them the whole of the Culebra can be placed out of reach of erosive curcents and can serve the splendid future of Panama. Here is the best and closest site upon which to deposit Culebra spoil rather than waste it at sea or spread it over the swamps at a heavy toll of life. And by this a new and greater Panama is created with an inner fresh harbor on Lake Panama matched by an outer harbor protected by the breakwaters, a combination unequalled in the water reaches of the globe.

As these inner fresh harbors and all the advantages they give cannot be available to a Sea-sevel canal, which is all salt water, they furnish one most vital point of preference over it. The Board did not include any harbor arrangements save the long Colon breakwater on the plea of cost. They state,—

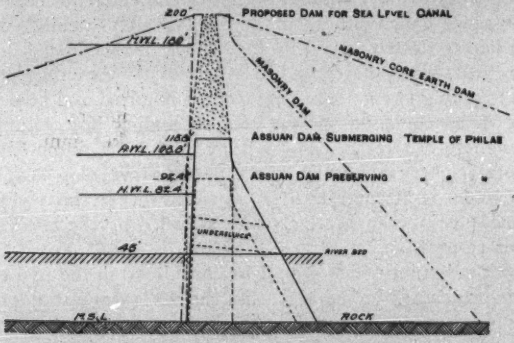
> "Much more *elaborate harbor constructions* and the more costly character of *their appurtenant works* chiefly account for the excess of the estimated cost of Mr. Bates's project over that of the sixty-foot summit level lock plan of the Board."

Since, however the proposer figured on contract prices rather than government execution prices, costs may not be so high as the Board estimates.

In the comparison of this lock and lake canal with the Sea-level, its far better terminal facilities of the sixty-foot canal are one point of superiority. Beyond this, however, every canal plan must be judged by the way it measures up against the elemental standards of security, cost and time of execution, convenience to navigation. It must stand or fall by the adequacy with which it meets these demands.

The first measuring rod for any canal is fundamentally the one of safety. The Sea-level scheme when it was presented to the Board included a three and a-half mile tunnel along whose

walls of volcanic conglomerate the eroding Chagres discharge was to tear, a disposition of the greatest danger. The revised Sea-level plan has not this objection. The adoption of the writer's Chagres flood solution has obviated this peril. The incorporation of a Gamboa sluice dam from which the regulated discharge, being divided, passes into the canal prism and thence goes to either ocean, has taken away the menace of the Chagres torrents for all normal conditions. But for a deviation from the normal, the Sea-level is still an unsafe canal and in an earthquake-visited tropic land this factor dare not be discounted. There is no guarantee against a repetition of the




*Sea Level Dam vs. Assuan Type:* The Sea-level dam is much higher and sustains a permanent lake. The Bates dam impounds no water, save in time of great floods.

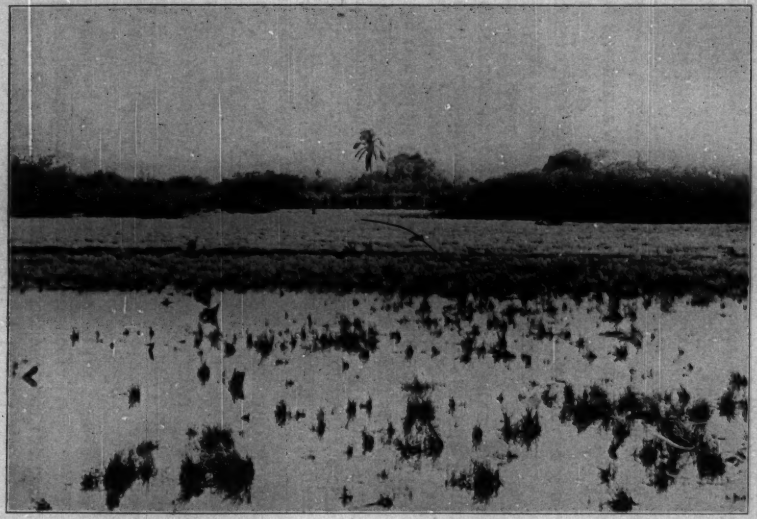
series of shocks which opened a gap across the main street of Colon and destroyed the Cathedral tower at Panama. The great permanent lake above Gamboa, on the latest Sea-level plan and the three others at Cano, Giganté and Gigantito, in the light of such possibilities, are three perpetual dangers.

Each dam holds back a deep lake at an elevation of from 55 to 170 feet above the canal. A breach in any of these three through an earthquake or subsidence, or fissure, or any of the other causes which make dams fail, would let loose a wave from 55 to 170 feet high to sweep destruction down the canal. As against this element of danger the sixty-foot canal as planned with the empty basin system has no high dams or high heads of

water like those four of the Sea-level. At Gamboa and Cano and at Alhajuela the sixty-foot canal has low dams, and instead of a permanent lake, the valley behind them is normally empty and no water is impounded save at floods. Only when an exceptionally heavy torrent comes are the sluices partly closed and water impounded, and this only for a maximum duration of fifty-six hours. The rest of the time the river flows quietly through the sluices. Five times in thirty years alone would it have been necessary to impound water behind the writer's proposed dams, for there were only five floods which could not have been allowed to pass the sluices. An earthquake, to have injured seriously the canal protected by these sluice dams with normally empty valleys behind, would have had to destroy the dam during one of the fifteen days in thirty years when there was water behind it. Any time during the remaining twenty-nine years, three hundred and fifty days, these dams could be shaken without finding any volume of water there to release. Three large deep lakes imminent and vulnerable every day in the year in the Sea-level plan as against three basins with water in them only five times in thirty years, is the measure of comparative safety afforded by the two canals in this respect.

A second point which should be considered in the two channels is, which will be the best from the navigator's standpoint? Very many railway engineers have been asked their opinion as to the canal, but very few of the principal navigators who will be called upon to take their ships through. But it is surely important for a waterway, which is built for the highest service to commerce, to know what sort of a canal a commander, anxious to score well with Lloyds and the ship owners, would prefer. First of all, he would want a straight entrance, clear of reefs and well protected. He would want a mooring place and a wharf space where he could have plenty of room. The harbor and the harbor entrances would be his first thought.

As to the canal proper, his demand again would be, plenty of room for steerage purposes, that there need be no danger of sheering against the sides or colliding with passing ships and plenty of water under his keel. Measure with such a standard as this and the superiority of the sixty-foot lock-and-lake canal,



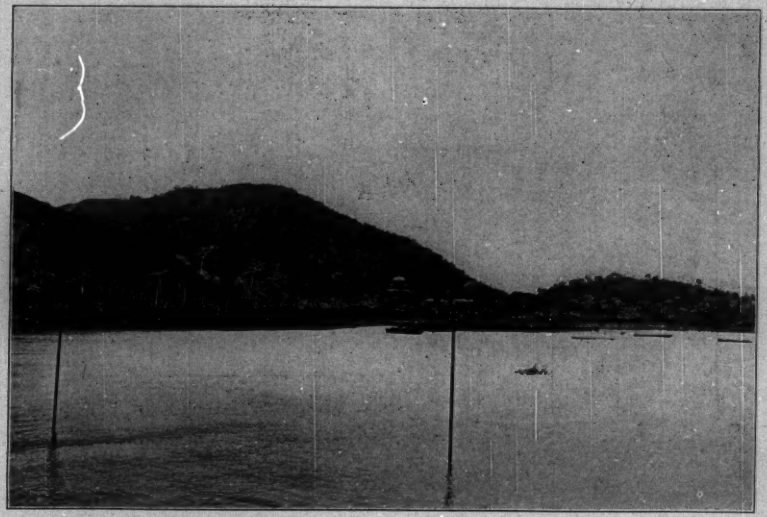
*Terminal Swamp:* These will be submerged under twenty-five feet of water, giving open sailing and making great sanitary improvement.

with the terminal harbors as elaborated, is not hard to demonstrate.

The Sea-level plan offers him, at Colon, a salt water bay whose approach is immediately to windward of Colon Reefs. At Panama it furnishes him nothing beyond the tide harried roadstead with an entrance directly across the San José Reefs. The harbors and harbor entrances of the writer's lake canal would be the best in the world, in the combination of a commodious outer harbor and inner water basin, free from tides, where the fresh water will kill barnacles and the ship worm, is ideal. The entrance contours are well beyond the reefs on each side and lead straight to the canal entrance without a curve.

On entering the canal proper, the navigator would, in the sea-level, start on his forty-six-mile passage through a constricted rock-flanked cut with the certitude that he would have to lay up for repairs if his vessel struck its walls. He must, all along the route, tie up in the pockets cut alongside the channel, and wait while other vessels passed him. He must move at very reduced speed in rounding all curves and so lose steerage way for two-thirds of the line. He must endure all the torment of the poison-laden swamps flanking him. At Culebra he would be deep down in an artificial gorge with the imminent clay-conglomerate towering above him on either side. Here and there he would have to squeeze by a dredge, clearing away the sediment brought down by the rain-swollen streams. The prospect to the navigator of insuring safe passage in a Sea-level canal at Panama would not be the most alluring.

The alternative which the sixty-foot canal holds out to him is open lake navigation for twenty-six and a-half miles, in which he could move at twice the speed which he could be allowed in a constricted channel. Other vessels could be seen for miles ahead, be allowed for and readily passed. There would be no sheering against banks, since ample steering room would be given. He would have no dredges to dodge, for all slit would be deposited where the streams enter the lakes, miles away from the canal, or be localized in special slit traps. For only nine miles through the Culebra would a channel exist such as the sea-level proposes for its entire length. But here the banks on either side would be much lower and so less dangerous as to



*The Ancon-Sosa Saddle:* The Pacific Lock is located here. It will lift a vessel about twenty-seven feet into Lake Panama.

land-slides. Because of the doubly greater speed, which a large ship could be allowed in a lake, its time of transit, counting in the lock passage, would be reduced by three hours. The ability to pass other ships, when the traffic of the future has become great, would be of incalculable benefit.

It has been testified that a certain Sea-level plan has less curvature than a lake canal. But such a statement as this is most misleading. When a vessel changes her course in a lake waterway the pilot does not reduce speed; in a Sea-level canal he must slow down. Applying this principle, it is the simple truth that a lake canal has but a third to a quarter of the curvature *affecting navigation* that the Sea-level scheme has.

Another standard for comparison is the time for construction. All other things being equal, a canal which can be traversed in eight or nine hours and can be available in eight years is better than one which demands three hours longer for a large vessel and which will not be ready for sixteen years.

Just when can a Sea-level canal be completed? Ten years is the latest figures of the ex-Chief Engineer for a canal forty feet deep. The Commission of 1901, making a careful estimate, gave twenty years as the minimum, and they were calculating upon only a thirty-five foot channel. Nine months ago the official figure for a thirty-five foot channel was given as sixteen years. The Commission now estimates eighteen years. Who, then, is to judge when doctors so disagree? Allowing themselves grace in the Majority's official figure, a forty-foot Sea-level channel across the Isthmus is to be, they claim, available in, at most, thirteen years. But it is only a much qualified estimate, based upon no guarantee whatever.

The truth of the whole matter is that no one knows at all, or can possibly know, when such a canal will be finished. If one goes over the list of the world's canals, having excavations of mixed materials and takes their rates of excavation, the result is surely a warning for the sanguine advocates of the Sea-level. The Chicago Drainage Canal was dug in one-mile sections by private contract, getting intimate personal supervision of the most interested kind and employing the most modern machinery. It was excavated at the rate of five and a-half million yards per annum. At this output a Panama Sea-level canal would require forty-seven years for its completion. Yet this

*The Assuan Dam :* A masonry dam of exactly this height and nature is proposed at Alhajuela and Gamboa to control the Chagres.

Chicago canal was dug in the temperate zone under none of the tropical conditions that will prevail at Panama. It had competent white labor. The Chairman of the Commission testified that Isthmian labor averaged one-quarter northern efficiency. The downpours, the lack of adequate labor, the rapidity of rot and rust, the illness and deaths, these may set the time for completion anywhere between fifteen and fifty years.

With the sixty-foot lock-and-lake canal, on the contrary, the time is not subject to the uncertainties involved in this huge mass of excavation. To make three low earth dams of standard type across the river valleys is easy and straightforward and an actual work of but few months. By making them, twenty-six and a-half miles of the canal's total land length of forty miles is turned into lake, needing incidentally but a small amount of soft dredging. An ocean steamer could then steam up to either end of the Culebra cut. The much smaller volume taken from the Culebra would be attacked by dredges or Lobnitz machines from either end, with water transportation for the spoil and by land plant with rail transportation as well. With such a program as this a minimum time may be realized and the canal can be contracted for under bond in at most eight years.

There is finally the extremely important question of cost. Assuredly no one wishes an inferior canal, be it cheap or dear. But dearness is in itself an element of inferiority, if the same or a better waterway can be had for less money. The fact that money is not the first and most important element is far from being a reason why it should be disregarded utterly. It is an axiom of political as well as business economy that the sacrifice entailed should not exceed the good gained. The good to be secured by an Isthmian canal may be measured fairly and accurately by the use which will be made of it. The Commission of 1907 made a minute investigatio of the commerce that would reasonably be expected to use the canal if constructed. They figured that, so regarded, the Panama justified as a national investment about the sum of $145,000,000 for its construction. Considering it as capitalized at this amount, and allowing ten years for its construction, the canal would thus just about repay interest and cost and yield enough for maintenance.

On the basis of these figures, Congress rejected the Nica-

rauguan proposition and invested $50,000,000 to secure title to Panama. Now the Sea-level proposition is brought forward, proposing a construction cost of at least $247,000,000. Sanitation and Zone Government, which were not included, bring the figure up to $263,000,000. This is to be paid out with no return for thirteen years and probably with some fifty years of deficits in income to follow that. The whole balance and equilibrium of the first conservative proposal is destroyed. It is not even claimed to be worth while as an investment. In bright generalities our astonished Congress is called upon to vote $128,000,000 more than was ever bargained for and to undertake a Sea-level canal with DeLesseps' technical and financial failure staring them in the face, and with each of its different advocates making conflicting estimates of time and cost.

Consider the figure set by the Board of Consulting Engineers, $247,021,200. The price of this revised Sea-level scheme is scaled to the lowest possible, leaving out items of great import in order to bring the figures down. The Panama Port Works, heretofore rated at $10,000,000, were omitted. Sanitation and Zone Government were omitted, though they are certainly indispensable and every previous plan included them as a matter of course. These features of sanitation and zone government must cost at least $16,000,000 more in thirteen years construction time. Add these items and the proper total becomes at least $273,021,200 on the Board's own unit prices. Is there any guarantee that this sum will not be exceeded? None whatever. The figure itself is simply an approximation. Detailed designs for engineers estimates under the new tropic conditions are not forthcoming. There is no assurance that the cost will not be more than $300,000,000, with a century's deficit in the canal's operation.

With the sixty-foot canal the same elements that make time calculable make cost calculable also. The impounding structures, which mainly constitute it can be closely figured. The excavation of which the Sea-level chiefly consists cannot. In French times the unit cost yer yard in the Culebra Cut varied from fifty-two cents to $6.80. In the small digging which we have had, it has varied from 50 cents to $1.54. Weather conditions, the amount of pumping, the difficulties attendant upon a huge force of crude labor, all are elements of hazard, far

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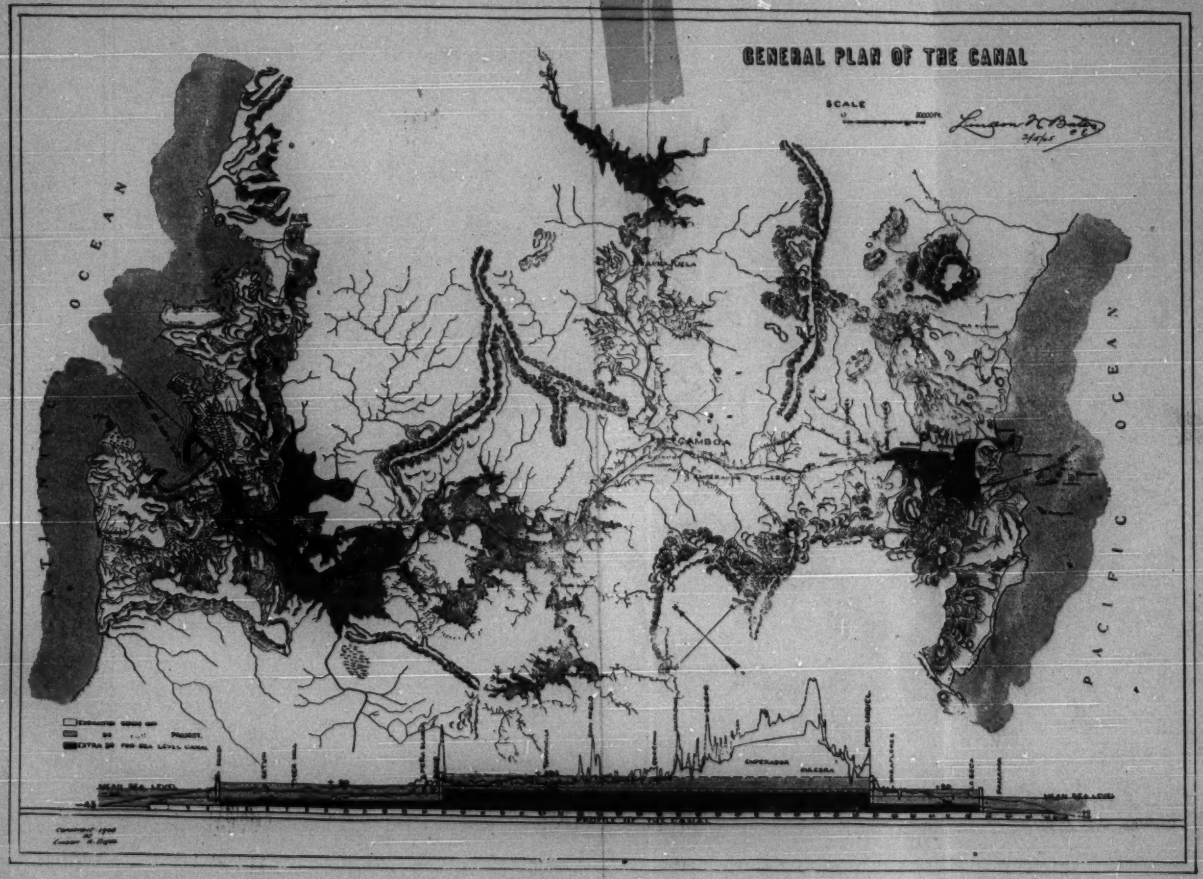
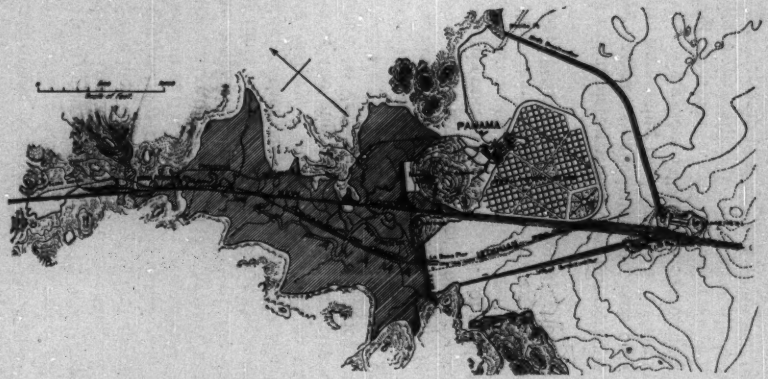


greater in the Sea-level than in any other type of canal. The maximum price figured by the majority was $176,000,000 as an engineer's estimate and $146,666,667 as a contracting estimate for their sixty-foot canal as planned, and they were committed to the Sea-level, a rival type. With the single modification (decreasing excavation) of adopting the Mindi site, there can be fully constructed the sixty-foot canal at $3,125,000 a mile, or a total of $124,000,000 construction cost, making with sanitation and zone government $135,000,000. The essence of the situation is that most of the Sea-level work is digging and this has a large element of uncertainty. Most of the lake-canal work is low structures of masonry, which has a very small element of uncertainty.

But assume that the Sea-level would cost $263,000,000, which is the Board's figure, plus the very moderate figure of $16,000,000 for sanitation and zone government. Take simply the difference that exists on the face of the estimates, $128,000,000, and consider whether the American people want to spend that amount extra to get a canal thirteen years hence which it takes a great ship three hours longer and much more hazard to pass through.

Congress passes periodically a River and Harbor Bill to improve our American ports. If this extra $128,000,000, which the Sea-level advocates assure us we can easily afford, were put into port works, what could be accomplished within our borders? The entrance channels to New York harbor, affecting every ship captain and owner doing business there, could be dredged out and established to forty feet, $10,000,000; the Cape Cod Canal could be cut $10,000,000; Portland, Oregon, could be made safely available to the largest vessels afloat, $6,000,000; Charleston Bar could be better jettied and so permanently removed, $7,000,000; the Mississippi Levees and port protections re-inforced, $11,000,000; San Diego Harbor dredged and made available to the largest vessels, $6,000,000; Chicago Harbor protected from northers by stone breakwater, $7,000,000; the Sacramento leveed and dredged, $5,000,000; Galveston Causeway to the mainland constructed, $1,000,000; and still there is $65,000,000 left for public buildings and improvements. This is what the spending of $128,000,000 in terms of things.

What is the gain of the Sea-level? In only one feature has




*Greater Panama:* The breakwaters and new town-site reclaimed from Culebra rock are shown and Lake Panama made by two short embankments and entered by the Ancon Sosa Lock.

it any claim to a superiority; the apparent advantage one lock over four. But their cost is made insignificant by the cost of the Sea-level excavation. The expense of maintaining them will be passed by that of keeping silts out of the one-lock canal. Any risk of passing them is more than offset by the risk of navigating a winding constructed canal. The time lost is more than decompensed by the lakes and made three hours shorter for large vessels. Is it worth while to exchange this illusory advantage of one lock over four, for the real advantages that accompany the features of the Lake Canal?

This question is not simply one of academic interest to be looked at from afar off as though it concerned a canal on Mars. One of the canal plans must be adopted, the others rejected. One canal must bear for all the future the commerce of the world, while the other plans are relegated to the dusty tomes of engineering history. The plan which is to pass from lines upon paper to the mighty waterway that cleaves two hemispheres cannot be determined by a sentiment or an illusion. The facts and all the facts must be weighed, considered and then definitely and finally acted upon. The conclusion which is indelibly engraven on the very nature of the facts is that the advantage of a Sea-level's one lock over a sixty-foot canal's four is too dearly purchased, at the cost of peril in each passage through its constricted, rock-flanked cuts; of the slower transit in its lakeless channel; of an extra expenditure of at least $128,000,000; of the retardation of completion by at least seven years.

There is a final matter which does not perhaps fall within the province of engineers called upon to face only mathematical possibility of harnessing the Chagres and piercing the Culebra, but which certainly does fall to the consciences of the nation commanding the work.

Under the project which the writer has advocated one year of work and every swamp near the canal line will be drowned beneath twenty-five feet of clean water. The number of laborers that would be used in a Sea-level would be reduced by one-half and the work would be largely done by water-borne machines. The stygomia larvæ could not live under such a depth of water, and if they could oil spread over an open and accessible sheet of water would kill them, where it could not be applied to the myr-

*Canal Entrance :* Between Ancon and Sosa Hills is the Pacific entrance. Both of these hills can be fortified.

iad isolated unreachable jungle pools. Terminal cities started de novo and begun rightly would supersede the old, around impregnated with filth germs from the garbage of half a century. New terminal cities on high ground, the fever swamps submerged, the use of floating dredges reducing the army of laborers—this is the supreme sanitary policy.

In that first Congress of 1879, where the foremost figure in the engineering world had swung his whole weight to the Sea-level waterway, one man rose up with his fatefully true prophesy against the great Frenchman's visionary ideal. This was Godin de Lepinay, the first man to propose terminal swamp-submerging lakes for the Panama Canal.

> "All my conscience is intensely enlisted. I am the only French engineer a member of this Congress who has executed work in that country there. If I have not known how to make my advice triumph, I cannot let it be believed that I abandoned it, all unknown though I am. I shall have gone out of this assembly, as others have done, that I may not leave my name subscribed to a measure disastrous.
>
> "Finally, and this is the greatest with me—me who has executed works in that tropical America; reducing these unsanitary works to their minimum, spares the life of more than 50,000 men, uselessly sacrificed for the execution of a sea-level project. To not charge my conscience with these unnecessary deaths and the loss of a considerable capital, I abstain, or I vote, No."

How true was his forecast the world knows too well.

A new generation of engineers now rallies to the old dream of De Lesseps,—forgetful of his silent buried cities. He, too, had great hospitals and disinfectants and new-built dwellings and a host of doctors. But could any sprinkling of chloride around camps, any screening of wires on windows, any water works or commissaries, any surface disinfection or spreading of oil remove the death that lurks in the steaming miles of jungle swamp that compass then round about?

For the greater part of its length, a canal dug at sea level must be cut down to its depth of forty feet below mean tide,

through the Isthmian morasses. To permanently drain these swamps is impossible. To fill them would be a labor of immortal gods, not of men. When the pioneers of the Panama Railroad undertook to drive one single line of railroad through to the foot-hills, it took them years and an appalling loss of life. What would be the price of life to fill them all, or to fill even a half mile strip along the canal? An army of doctors and "weeding engineers," with all the resources of modern science, could not kill the stygomia larvæ in the myriad isolated festering pools, and just so long as these swamps are allowed to breed death just so long will the Isthmus be the white man's grave. What must result when excavation begins in earnest and ground is newly broken all across the Isthmus, is not hidden. It can be read on the tombstones of Monkey Hill; in the tragedy of Matachin, "slain Chinese village;" in the cluster of drooping crosses behind Ancon, in the bitter legend of a lost man, warden of each rail of the Panama Railroad. Just as surely as the rising of the sun, a decision for a Sea-level canal dooms to death an army.

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## THE SALTON SINK.

A map representing parts of California and Mexico has recently been published by the United States Geological Survey which is of unusual interest at this time. The area covered is widely known as the Salton Sink, a great depression in the Colorado Desert which has been much discussed lately, owing to the threatened formation of a large inland sea where there is now a thriving community.

About 8000 people have settled in that part of the basin known as the Imperial Valley, and are raising excellent crops of barley and alfalfa. Stock farms are numerous and experiments in raising the date palm are in progress. The freight shipments from Imperial, a town only four years old, rival those of Los Angeles in value, and are said to exceed those of any other town in Southern California.

The existence of this peaceful community is, however, seriously endangered by Colorado River, which, strangely enough, is also the source of all its prosperity, as it is this stream which furnishes water for the irrigation system. The absence of any controlling work at the head of the main canal has resulted in diverting the river from its old channel and permitting the entire flood flow to enter the irrigating system. This is causing great damage to the ditches and crops, and is forming a large lake, which now

covers about 250 square miles, at the lowest part of the Sink. The Southern Pacific Railroad has been obliged to rebuild many miles of tracks.

The map of this region, which is called the Salton Sink Special, shows on a scale of about eight miles to an inch, all the principal towns, roads, canals, and drainage lines. Contour lines also indicate what the future sea may cover at different altitudes. The usual price of five cents a copy will be charged for this map, which was made by Mr. W. Carvel Hall, under the direction of Mr. R. B. Marshall.

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## A REMARKABLE SODA SPRING.

By J. A. Eddy.

Undoubtedly one of the most remarkable springs in the world has recently been discovered in New Mexico. It is literally a spring saturated with sodium sulphate. Distilled water weighs 8.33 lbs. to the gallon. The water of this spring weighs 10.66 lbs. per gallon; and evaporation yields 3.13 lbs., of dry solid matter, of which 83 per cent. is sulphate of soda, crystallizing out chemically pure.

The sulphate of soda crystal contains 87 per cent. water. At 110 degrees F. it melts in its own water of crystallization; and the temperature of the spring being slightly in excess of 110 degrees F., the saturated liquid upon flowing and cooling immediately forms a crystalline mass like ice.

The natural inquiry arises as to the deposit or accumulation of ages from this spring; for, unless it discharged into a stream of fresh water, the deposit would be vast in extent. No more fitting location could be imagined, for it is in the lowest portion of the vast sink or basin, scores of miles in extent.

The deposit therefore has formed a vast bed, miles in extent, of solid sodium salts, through which this spring, by reason of its heat, maintains its channel and continues to augment the deposit. Inasmuch as the soda crystal efflorescences, or gives up its water by evaporation, the elements serve to smooth and level the surface; so that the lake, though dry, is white as snow and bears some resemblance to a Northern lake in the embrace of winter.

It would seem impossible for either animal or vegetable life to exist in this hot brine, or in the dry soda of the lake surface; and yet the brine is inhabited by a minute shrimp-like organism, and a species of plant is often found thriving in the pure white sodium sulphate.—*Eng. and Min. Journal.*

## Section of Physics and Chemistry.

(*Stated Meeting, held Thursday, May 3d, 1906.*)

# The Scouring of Cotton.

By J. Merritt Matthews, Ph. D.

Professor of Chemistry, Philadelphia Textile School, and Lecturer on the Chemistry of Textiles and Pottery, Franklin Institute.

1. *Introductory.*—Before cotton can be properly dyed or bleached, it is necessary that the waxy matters surrounding the fibres should be removed. As these are water-repellent, it is very difficult to impregnate the cotton fibre with solutions if such impurities are present. This may be rendered easily apparent by placing raw cotton in water, even at a boiling temperature, and noticing how long a time is required for the fibres to become wet through.

Unless it is to be dyed or bleached in the loose state, cotton in this form, is seldom scoured out, as the amount of foreign matter on the fibre is nowhere comparable to that on wool, and it in no way interferes with the carding or spinning. In fact, the waxy matters on the cotton fibre are of great assistance in the proper carding and spinning of the material, as it gives a coherence to the fibres which would otherwise be lacking. Cotton that has been scoured and bleached in the loose state is very difficult to properly spin, and oil must be added to the stock in the same manner as with wool.

2. *Nature of Impurities in Cotton.*—The cotton fibre, though usually considered as consisting of practically pure cellulose, contains about five per cent. of foreign matter other than the true fibre. The majority of this consists of a thin layer of vegetable wax and pectin, which forms a coating over the surface of the entire fibre. This wax, as already noted, gives the raw cotton fibre its water-proof or water-repellent character, and is also very serviceable in giving the fibre a certain degree of plasticity during the spinning operations. Underneath the layer of wax

is a very thin cuticular tissue, which also covers the fibre proper. This, no doubt, consists of an alteration product of cellulose, produced through the action of the air, and merely acts as a limiting surface to the matrix of cellulose beneath. In the inner portion of the fibre, forming the wall of the central canal, there is also a very thin integumental tissue, or skin, which is, perhaps, of somewhat the same character as the outer skin. Within the canal itself there is also always more or less dried-up protoplasmic matter, consisting of nitrogenous substances and resinous matters derived from the dried-up sap, which during the life of the fibre circulated through this canal. There is also a small amount of oily matters present in the fibre, derived, no doubt, from the oil of the cotton seed, and contaminating the fibre as a result of the process of ginning. Finally, the cotton fibre contains a minute quantity of coloring-matter, doubtless of a catechin-tannin variety. In some varieties of cotton, as in the Egyptian and Nankin, this coloring-matter may become quite pronounced, and give to the fibre a distinct yellowish-brown color.

It is customary to consider the impurities of the cotton fibre under two general headings: *(a) cotton wax*, and *(b) pectin bodies*; the latter consisting of the albuminous or nitrogenous substances already spoken of.

Dr. Schunck has made a careful investigation of the impurities existing in the cotton fibre, and the following summary of his results may be given: Besides the hydroscopic moisture, crude cotton appears to contain about five per cent. of non-cellulosic matters, which may be classified as follows:

*(a) Cotton-wax*, bearing a strong resemblance to carnaüba wax; it is insoluble in water, but soluble in alcohol and also in ether.

*(b) A fatty acid* which has a melting point of 55.5° C., and appears to be either margaric acid or a mixture of palmitic and stearic acids.

*(c) Two brown coloring-matters* of a nitrogenous character; one is easily soluble in alcohol, and the other but sparingly so.

*(d) Pectic acid*; a light yellow amorphous substance, similar in character to gelatine or a gum. It is soluble in water, and is acid in reaction. It exceeds all the other constituents in amount.

*(e) Albuminous matter* of a nondescript character.

*3. Theory of Cotton Scouring.*—The process of cotton scouring is most generally spoken of as "boiling out." The state in which cotton is usually operated on is either yarn or cloth; loose cotton is only scoured when it is desired to have it bleached in this form, more especially for the preparation of absorbent cotton or for use in cotton bats. Cotton yarn and cloth, however, must always be thoroughly scoured previous to bleaching, and also frequently before dyeing or mordanting; although in the latter case, the object of the scouring is only to cause the cotton to wet-out readily and absorb the solutions with which it is treated; consequently the scouring in this case is by no means as thorough as when it is desired to subsequently bleach the cotton, when all the impurities must be completely removed.

There are two general processes by which cotton may be scoured; the one is by the use of alkalies, such as soda ash, caustic soda, or lime, whereby the waxy matters on the fibre are removed in the form of an emulsion, and the pectin and other matters are decomposed by the alkali into soluble substances; the other method is by the use of certain oils, such as Turkey-red oils, sulphated cotton-seed oil, etc., whereby the waxy matters are dissolved-off and very rapidly removed from the fibre; although the other impurities are but slightly affected. The former method removes or decomposes all of the impurities, whereas the latter only removes the wax and makes the cotton absorbent towards water, so that it may be readily dyed. In some cases of bleaching, both methods are combined, and as we shall afterwards see, both possess certain special advantages of their own.

The treatment of cotton in scouring or boiling-out, will depend on the purpose for which the cotton is intended. If the scouring is merely for the purpose of wetting-out the fibre so that it may be more readily dyed, then the scouring is only a partial one, chiefly with the object of removing the waxy matters. If, however, the scouring is for the purpose of completely cleansing the fibre of all impurities in order that the cotton may be well bleached, then the boiling-out is a very thorough one. We will discriminate between these two methods by calling them "wetting-out" and "boiling-out."

To obtain the best results, cotton yarn or cloth should always be wet-out thoroughly before being dyed or mordanted, as if this is not done, there is danger of having spots or uneven streaks through the goods, by reason of insufficient penetration of the dye liquor. In the case of some dyes where the color goes on very slowly and evenly, and where the material may be boiled a long time in the bath before the dyeing is finished, this previous wetting-out may not be absolutely necessary, as the boiling water itself brings this about. This is usually true of the general class of substantive cotton dyes, though in this case a small amount of alkali or oil may be added to the dyebath itself, and in this manner the wetting-out is greatly facilitated. In case of dyes which go on the fibre quickly, or which dye at temperatures below the boil, it is almost an absolute necessity to have the cotton first wet-out before placing it in the dyebath. The same is also true in the case of mordanting, especially so, as cotton does not possess any great degree of attraction for the majority of mordanting salts, and unless well wet-out the fibre will only be poorly mordanted. In the case of mordanting with tannin, where a boiling bath is used (as is sometimes the practice), the previous wetting-out operation may be dispensed with, and the cotton wet-out in the mordant bath itself; the same is also true when the cotton is steeped in the tannin bath over night; but where the tannin bath is used at a lower temperature that the boil (as is most frequently the case), the cotton should always be first wet-out, otherwise when the material is dyed, small white specks will show up, caused by lack of penetration of the mordant.

For the proper bleaching of cotton goods it is absolutely essential that all of the foreign matters present in the fibre be removed, in order that the cellulose be pure and that a good clean white be obtained. This is true both where the cotton is bleached for the purpose of being left in the form of white goods, and also where it is to be subsequently dyed with such coloring-matters as alizarin for Turkey-red, and for the general purposes of printing. In the two latter cases the bleaching must be especially thorough in order to obtain the best results in dyeing and printing. These processes are more especially used on cloth; for yarn the bleaching does not have to be so thorough. As the boiling-out of the cotton is so intimately

connected with the actual process of bleaching itself, and as the one process really forms a continuation of the other, the two must be considered together under the one subject of bleaching.

Cotton which is intended to be dyed cold should be very thoroughly scoured, otherwise the dyeing will be imperfect. Also yarns made from Makko, or Egyptian, cotton require a more thorough treatment than usual, as they contain more fatty and waxy matters than ordinary yarn. In the scouring of very fine yarns the material should be enclosed in sacks in order to prevent it from becoming felted.

*4. Scouring Cotton with Alkalies.*—The usual method of wetting-out cotton with alkalies is to boil it for an hour or two in aweak solution of soda ash. After this process it is washed in clean water, and is then ready for dyeing. A weak bath of caustic soda may also be employed for this purpose, but this is not used as much as the former. Caustic soda is more difficult to remove afterwards from the fibre, and so causes loss of time in unnecessary washing, whereas liquors of soda ash are very readily washed out of cotton, and even in many cases, the washing may be entirely dispensed with, when the dye-bath to be used is alkaline in character. It requires at least an hour's boiling in the bath of soda ash before the cotton will be completely wet-out, although the operation should not be limited to any fixed time but should be continued until it is seen that the material is thoroughly impregnated with liquid; in the case of yarns, the inside of the hanks should be opened out and examined for any dry spots. Tightly twisted yarns will naturally require longer to wet-out than single and loosely twisted yarns. Sometimes yarns are spun with the addition of oil to the stock, in which case it is advisable to add a small amount of soap to the scouring bath.

Müller has studied the effect of different alkaline agents in the wetting-out of cotton for dyeing, and the summary of his results are as follows: Using a pure, well-made soap wets-out cotton better than a sulpho-ricinoleate, olive oil soap giving the best results and palm oil and olein soap a slightly inferior result. In using a hard water it is necessary to add some soda ash in order to obtain good results.

*5. Scouring of Cotton with Oils.*—It has been found that certain oils possess the property of readily dissolving waxy mat-

ters present in the cotton fibre, so they may be used for the purpose of wetting-out cotton for dyeing. The oils referred to fall under the general class known as sulphated or soluble oils, of which Turkey-red oil is the principal representative. Turkey-red oil is so called because it is largely used in the mordanting of cottor for the subsequent dyeing with alizarin for the production of a bright red. True Turkey-red oil consists of sulphated castor oil, produced by the action of concentrated sulphuric acid on castor oil. The resulting product is an oily looking substance which is soluble in water. Other vegetable oils may be used for the same purpose, and sulphated cotton seed oil is largely used, as it is considerably cheaper. A number of proprietary preparations of these oils are on the market, among which may be named Fankhausine, Solvine, etc. Some of them also contain small amounts of mineral oil, and some contain alkali, soap, tallow, etc., for the purpose of softening the cotton. They are known under the general name of "cotton softeners." Scouring with oil leaves the cotton in whiter and softer condition, the time required for wetting-out is much lessened and the scouring can be done at a much lower temperature. The amount of oil to be added to the bath need not be more than one to two per cent. on the weight of the cotton, and in many cases it may be added directly to the dye-bath, and the cotton be wet-out before the coloring-matter is added. In almost any case, it will hardly be necessary to wash the cotton off after scouring, as the small amount of oil which would be carried over into the bath would have no effect on the dyestuff. In the case of basic dyes, however, the oil cannot be added directly to the dye-bath, as an insoluble compound with the coloring-matter will be formed. When mordanting with tannin, also the scouring must take place in a separate bath.

Turkey-red oil causes a considerable bleaching of cotton when used for boiling-out; in fact, Hartel claims that a pure white can be obtained in the following manner: The cotton is impregnated with a solution of Turkey-red oil of about ten per cent. strength, wrung out and dried. The material is then boiled for six hours under pressure with about two per cent. of caustic soda, rinsed, slightly scoured, rinsed again, soaped slightly, rinsed and finally dried.

## Mechanical and Engineering Section.

# Testing and Inspection of Railroad Supplies.*

By Robert Job.

Chemist of the Philadelphia & Reading Railway Company.

In the time at our disposal to-night it will be impossible to give more than a very brief outline of some of the more important testing regularly carried on by the Philadelphia & Reading Railway.

The main object of the Test Department is to determine the kind and quality of material most efficient and economical for any given purpose, and then by means of routine tests to hold shipments fully up to the desired standard. The plan usually followed is to get together all the information obtainable regarding the particular article to be investigated, decide through study of service tests just what properties are essential to the greatest efficiency, and then work out specifications which will enable the manufacturer to understand thoroughly just what kind of material is desired and what tests must be met to insure acceptance of shipments.

These proposed specifications are referred by the Purchasing Agent to the manufacturers for their criticism, the replies are sent to the Chemist, and a final draft is then prepared with any changes necessary, submitted again if needful to the manufacturers and finally to the First Vice-President for approval.

Orders are then placed in accordance with the new standard, and on receipt of each shipment a sample is selected at random and forwarded for test. If the sample is not in accordance with the specifications the shipment is rejected, and the freight is paid by the shipper. In this manner inferior material is weeded out from the good, and discarded.

*Read by title.

Iron in one form or another is, of course, an important item of railroad supplies. Bar iron, and the better grades for bolts and for staybolts come under this head, and also rivets, steam pipes, boiler flues, chain, iron castings, wheels, etc.

The quality is determined in part with the so-called "test machine," by which the tenacity and ductility of the metal are measured;—the cold bending test develops any cold-shortness, if present, and the hot bend any red-shortness or failure to bend when red-hot. If too much sulphur is present the iron will crack on bending hot, while excess of phosphorus will cause cold-shortness. More than a trace of copper will prevent proper welding,—and too little working in the rolls, or finishing at too high a temperature will result in brittleness, and be indicated by the bright granular condition of the fractured surfaces, instead of the long, ropy, fibrous appearance indicative of toughness and strength.

The pig-iron used for making cylinders and other castings must be low in phosphorus or the metal will be weak and brittle,—not too high in manganese and sulphur or it cannot be machined,—and close-grained and compact to insure strength and impermeability. Analyses are made of samples from each carload of pig-iron to hold it to the proper quality, and the foundry practice has been carefully studied, and treatment is applied to render the iron tough, strong and ductile.

Tests of cast-iron wheels for freight cars are made at the place of manufacture and involve measurements and weight and general inspection, and a "drop test" made by allowing a weight of 140 lbs. to fall upon the wheel from a height of twelve feet a specified number of times, depending upon the weight and size of the wheel,—twelve blows for the usual 33″ wheel.

Materials of steel are of great importance, since they include such products as boiler steel, axles, rails, splice plates, springs, piston rods, crank pins, castings, general forgings, building material, etc. In fact, the very stability of the structures, the engines, and equipment depends in large degree upon the quality of the steel and iron. In the case of boiler steel, a test piece is taken from every sheet and given a tensile test to ensure the desired strength and ductility, freedom from flaws, etc.; a bending test is made after quenching, to avoid possibility of brittle-

ness, and also chemical analysis to determine and bar out more than a certain proportion of phosphorus and sulphur.

Steel rails, splice plates, axles, piston rods, crank pins, and springs, are inspected at the manufacturing plant. Each spring is pressed down solid in a testing machine, and must also have a certain height under a given load, be of correct design, etc. Also an analysis is made of one spring of every 200 to determine whether the steel may be depended upon to give good service.

Axles in addition to the usual surface inspection and measurement are subjected to a drop test to ensure freedom from brittleness, and they are also held to a definite composition to enable them to support the loads and give reliable service. Rails likewise have composition specified to secure proper hardness and toughness, and a drop test is made upon a rail-butt from each heat from the top of an ingot, allowing a 2000 lb. weight fall a distance of twenty feet striking the rail midway between two supports four feet apart. If the steel is brittle and unsafe for use, owing to defective manufacture, pipes, flaws, etc., this 40,000 foot-pound blow speedily renders the fact evident and breaks the rail, sometimes into splinters. In some cases, especially when steel has given poor service, it is necessary to make a miscoscopic investigation of the structure of the metal to find out the exact conditions of heat-treatment received in course of manufacture, for as is well known, good steel can be completely ruined by incorrect heat-treatment. If the steel was overheated or burned, and thus was rendered brittle and untrustworthy, the fact is clearly shown by the microscopic structure.

Passing now from iron and steel, we may mention protective coatings for metal or wood. Paints to-day are used in enormous quantity, and it is of great importance to obtain the utmost durability not merely in order to afford the necessary protection and appearance, but also to reduce labor costs and to avoid the need of frequent shopping of equipment and consequent withdrawal from urgent service. The paints are separated into their constituents and the purity or efficiency of each is determined. The linseed oil must not be of poor quality or adulterated with fish oil, mineral oil, corn oil, etc.; turpentine must be really turpentine and not benzine; and japan must be up to the specified strength and quality.

"Hot boxes" are generally due to difficulty with oil, wool-waste, or bearings, and each of these materials are held to a definite standard. A week often passes without a single hot-box upon any of the passenger equipment of the Reading.

Wool-waste for freight service must contain at least sixty-five per cent. of pure wool and be of fair length of thread, or the waste after short service would lose its elasticity and fail to remain in contact with the journal, thus cutting off the feeding of the oil to the axle.

The oil must have correct flashing and burning points, be of proper viscosity and have enough fat oil to make the mixture adhere to the steel. Signal oil must be of standard composition and quality so that the wick in the lamp will hold the flame in a gale of wind; headlight oil must not explode even when hot and jolted.

Also each kind of machinery must be lubricated with oil adapted to its weight and speed,—or loss of power, heating, or rapid wear will result, with heavy bills for maintenance or repairs.

Air-brake hose must stand a pressure of 400 lbs. per square inch, and the rubber must be tested to prove whether or not it is so adulterated with shoddy, mineral matter, paraffine, tar, etc., that its life will be gone and it will be useless within a few months. The battery materials to operate the electric track signals with which our tracks are protected must be found so free from impurities that the service rendered will be absolutely reliable.

Portland cement is very largely used in construction work, and gives excellent results when the quality is good. It may, however, be unsound and cause the work gradually to disintegrate, or it may be shipped out by the manufacturer while it is too fresh,—not properly aërated,—and if used then the concrete would not prove lasting but would crack and weaken; in these cases careful tests indicate the quality, and they often keep from service material which would have caused failure and perhaps accident.

The water supplies, both for steam and for drinking purposes, also require careful attention. The former must be of a character that will not corrode the boiler, nor on the other hand fill it with scale and necessitate frequent cleaning of the flues,

and waste of fuel, since scale one-eighth inch thick means a loss of fuel of twenty-two per cent.; also, the character of the water must be so regulated when necessary by treatment, that foaming and liability of explosion will not be possible.

Every water supply upon the Reading is tested from time to time; bad waters have been abandoned, and other supplies substituted, or, if nothing better is available, treatment is applied to neutralize the injurious results which otherwise would follow.

Every water used as a drinking supply in stations or upon cars has also been carefully analyzed to be certain that it is as free as possible from contamination.

Whenever desirable, bacteriological examinations are made to determine whether a water supply in some locality may have become contaminated and caused typhoid fever or other disease which developed.

Tin plate and roofing tin sometimes have so thin a coating of tin or composition that rusting begins after exposure of a day or two upon a roof, and we have actually received shipments in which the thickness of the tin coating averaged less than 3/100,000 of an inch. Such material of course has little practical value other than that of the steel sheets of which it is composed, and the latter could be secured at far less cost than probably would be charged for the so-called "tin plate."

Insulated signal wire is tested to determine whether the copper is pure, and the rubber and other insullation of standard quality.

Soap must be free from excess of alkali, salt, and other impurities, and must not be adulterated with clay or other "fillers," and must not contain more than a definite proportion of water.

Enough instances have now been cited to convey some idea of the great variety of tests and inspections regularly made by the Test Department. In addition to such routine work, investigations are made upon materials which may have given unsatisfactory service, or which apparently have not been exactly adapted to the conditions under which they were used, in order to determine just why the failure occurred, or the service was defective, and the data thus obtained often results in revision of specifications with consequent improvement.

Investigations are also made to devise new methods for use

or renewal of waste materials or to develop new processes, large savings having been effected through such work.

The preservation of wood is a subject of the greatest importance to every railroad, and a very careful investigation has been made of all processes used and results obtained both in this country and abroad; also tree-planting upon the land at our disposal has been looked into thoroughly and estimates obtained as to the cost and ultimate return from such investment under our conditions of place and climate.

From the foregoing brief account of work of the Test Department, the fact will, I think, be evident that a persistent and earnest effort is being made to secure the grades of material best adapted to the various purposes, and such effort naturally results in relatively great durability of material, and thus in great ultimate economy combined with a high degree of safety and of efficiency in the service.

READING, PA., Feb. 16, 1906.

*(Stated Meeting, held Thursday, April 5th, 1906.)*

# The Design, Installation and Maintenance of the Modern Office Building.

By Chas. Gobrecht Darrach, C.E., Etc.

As experience in any art is of prime importance, to one who has to speak about that art, and as the speaker's experience in designing the mechanical equipment of office buildings has been a long one, he ventures to think, that a paper, based largely upon it, will be of more service to the Institute than one, however carefully prepared, but based upon information acquired in a less exacting school.

He says this because he wishes to apologize, once and for all, for the personal note, which appears in this discussion, and which he fully realizes to be, if undesirable, yet of unavoidable frequency.

He trusts that a free discussion will not only mark his errors, but also elucidate more fully those important subjects which he attempts to bring to your notice.

The modern office building is a national triumph, and in our own city one of the first office buildings was erected—the Bullitt Building, opened for use about 1887. I think the Empire Building, in New York, was the precursor, but neither of these buildings were fireproof.

Community of interests, required the study of the needs of the various tenants and of the ways and means to serve them, both individually and collectively, not only with all modern comforts, but also with all the varied apparatus of the most advanced science, at such a cost of service, that the old system of seggregation of offices would be abandoned.

The office building became a city. The tenant, with the advantage of absolute privacy, possessed the means of perfect communication with the outside world, and could be reached

in person or by voice, by telegraph or by letter, as readily if desired as could the greatest magnate of the land.

It was not long before these advantages were appreciated, and individual offices in separated buildings, became not only suburban, but as it were isolated in some vast prairie.

It is my purpose this evening to give a brief review of the design, construction and of the mechanical installations required to meet the necessities of these internal business centers, vieing in population and importance with many of the larger cities of a quarter of a century ago.

The development of science was the precursor of the office building, and I think you will agree with me, that except in magnitude, in some minor improvements in apparatus, and the addition of a few luxuries, the designers and engineers of twenty years ago solved the problem.

## DESIGN AND CONSTRUCTION.

### DESIGN.

Looking backward to the Drexel Building, in Philadelphia, designed in 1886-7, the following cardinal points were considered and fulfilled to the then state of the art:

*1st.* That the building should be fireproof.

*2nd.* That the means of ingress and egress should be so arranged, that no matter where located, the various offices should have equal advantage.

*3rd.* That the building should be so designed that the greatest proportion of rentable floor-space could be utilized and that, that space could, without structural change, be subdivided into a minimum sized office, lighted by one window, and at the same time be provided with all the conveniences of the larger subdivisions.

There are but few of the best modern office buildings which fulfil these conditions, and the only additional advantage which the tenant appreciates is, that he has, in his office, a hot water tap and a cold drinking water faucet.

To enumerate the conveniences, in addition to those heretofore mentioned, there were provided:

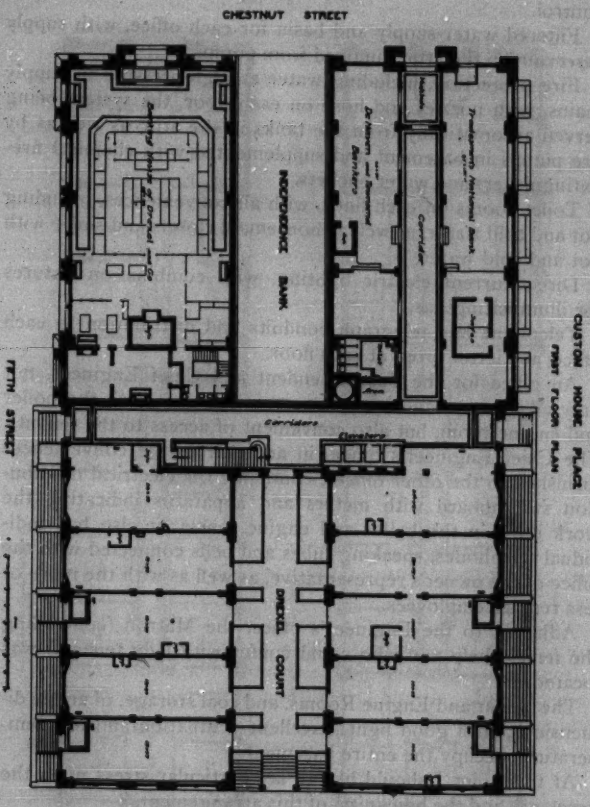



Illustration Special Floor. (1887.)

High-speed elevators, with safety devices.

Steam heat, radiator under each window and under individual control.

Filtered water-supply and basin for each office, with supply reservoirs in the attic, supplied from pumps.

Fire protection, including water at high-pressure in supply mains, with nozzles and hose on each floor, the system being served automatically from the tanks in the attic as well as by fire pumps in basement and supplemented with chemical fire-extinguishers and water buckets.

Toilet rooms on each floor, with all conveniences, including hot and cold water, as well as housemaid closets and sinks with hot and cold water.

Direct-current electric lighting, with combination fixtures for illuminating gas.

Telephone and telegraph conduits and distribution to each office, and letter drops at each floor.

An office for the Superintendent and Chief Engineer, not only adjacent to and in direct communication with the boiler and engine room, but also convenient of access to the tenants. The Chief Engineer's office, in addition to the conveniences furnished to the other offices, contained the electrical distribution switchboard with meters and apparatus indicating the work done in the boiler and engine-rooms; it also had individual telephones, speaking tubes and bells connected with the office of the owner's representative, as well as with the more or less remote employees.

Adjacent to the Engineer's office, the Matron (controlling the female help and who could confer with lady tenants) was located.

The Boiler and Engine Rooms, and coal storage, of ample dimensions, with good light, excellent ventilation and low temperature, occupy the entire basement,

At this point I should like to lay particular stress upon the necessity, and the humanity, of this arrangement.

Of necessity, the working parts must, if efficiency is to be expected, be in view and subject to easy inspection and repair.

Apparatus crowded together cannot but escape the attention of the Chief Engineer and Superintendent, who has the burden and responsibility of the entire management, including not only

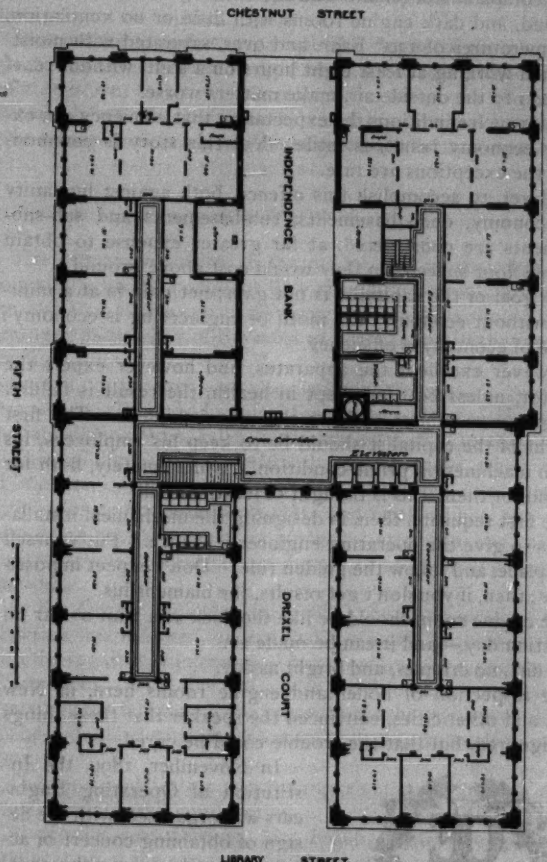



Illustration Typical Floor. (1887).

the apparatus but also the personnel of the employees, as well as the complaints of tenants and the criticisms of the owner, on his mind, and dark engine rooms with little or no ventilation, in temperatures of 130° Fahr. and over, saturated with moisture, men working at least eight hours on a shift, without relief or access to the outside air, make matters worse.

Under such conditions the expectation that efficiency can exist, or economy result, is futile. Yet this story is commonplace, the exceptions are rare.

And yet, to accomplish this offence, both against humanity and economy, deep basements, sub-basements and sub-sub-basements are constructed, at far greater expense to obtain rentable floor space than they would cost above ground.

The goal of the capitalist is net gain; net gain is at a minimum without economy; the motif of engineering is economy; the life of economy is efficiency.

However excellent the apparatus, and however expert the operator, unless both are kept in health, the result is failure. The gun is worthless without the man behind it. The first thought of the capitalist should be to keep his employees, his human machines, in prime condition. Unfortunately, both for him and for them, this is thought of least, if at all.

The first requisite, then, in designing the mechanical installation, is to give the operating engineer a chance. Put yourself in his place, and follow the golden rule. Don't expect impossibilities; then, if you don't get results, the blame is his.

The engine room should be like the deck of a man-o'-war on inspection day,—and it can be made so.

No dirt, no cripples, and bright as day.

The inspection of boiler and engine rooms here, in New York, and other cities, convinced the speaker that these things were ignored, but that the trouble could be cured.

In November, 1899, the Institution of Operating Engineers was organized, with the design of obtaining concert of action, not only among the operating engineers, but with them also among the designers, capitalists and owners. The effort

has been crowned with success, so far as the engineers were concerned; but I regret to add that the capitalists and owners have given it no encouragement.

It is not my purpose to go into the details of the manifold specialties or methods of design, which go to make up the complex organism under consideration,—but simply to give a few historical facts, so that we may trace the progress made and give some points which may be of service.

## CONSTRUCTION.

The primary requisites in the design and construction of a community building are that they should be not only fireproof, but also that all the apparatus serving the tenants should be so arranged as to allow of the most radical change in the interior arrangements.

One, if not the first, example aiming at these results, was the Pennsylvania Railroad Terminal Station and offices, designed by the late Wilson Bros. & Co., and completed 1878 to 1880.

This building had (except for the outside walls, which were of brick masonry), an interior framework of steel construction, with concrete floors on terra-cotta and brick arches, and with terra-cotta partitions, but no particular attention was paid to the arrangement of the service apparatus to allow of change of partitions.

In the Drexel Building (1886-1888) the same motif of construction was followed, except that the entire frame was steel, with the requisites of arranging and providing for modifications of partitions. That this was a wise provision has been demonstrated by the fact that at the present time the number of offices has been doubled without structural changes, except as to partitions.

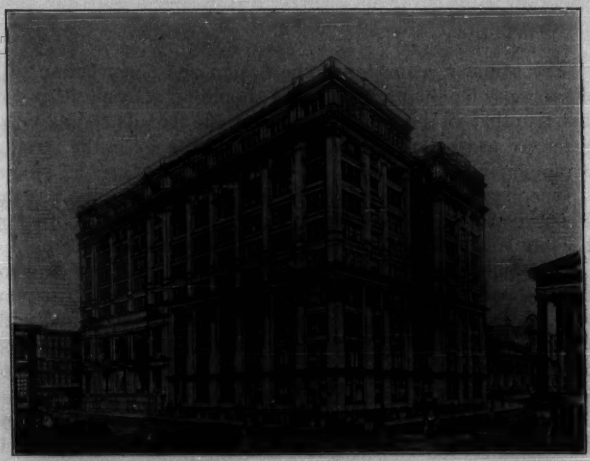
The next modification was the introduction of the now well-known curtain wall construction.

About the year 1888-89, Mr. Frank Furness suggested a modification in the construction of concrete floors, by utilizing a reinforcement of steel rods so disposed as to obtain the full value of the compressive strength of the concrete in cross-strain, at once not only reducing the cubic contents or unpro-

ductive space occupied by the floor construction but also very materially reducing the cost.

This was not, however, the first time that steel reinforcement was attempted since the late Dr. Ludwig Y. Filbert introduced steel members in the construction of cement pavements as early as 1876.

The early attempts were not always attended with success, as the laws which govern the construction were not fully known until the present time, when, as you know, we are as well, and



The Drexel Office Building, Philadelphia.

better informed probably to-day of the laws which should govern the concrete construction as with those on which to design metallic, timber or masonry construction.

So that the construction of the modern office building, except such glass, wood or other materials as may be necessary for decoration and comfort is *par excellence*, reinforced concrete, or what is sometimes called Concrete Steel.

In the present state of the art all combustible trimmings can be supplanted by fireproof materials, so that fireproof floor coverings, doors, window frames and mullions, as well as casings,

etc., can be constructed as easily as of wood, the skylights and the upper sash of the windows may be glazed with wire glass, and at a cost, probably not much more than if constructed by present methods.

By such construction the devastation caused by such fires as destroyed Chicago, Boston, Baltimore and San Francisco would have been impossible.

The earthquake and fire at San Francisco, which happened after this discussion was read but before going to press, emphasizes the value of the methods of construction proposed.

### CONDUITS.

Conduits for all the probable electric lighting, power, telegraph, telephone and bell circuits should be provided and constructed with the buildings, arranged to serve any arrangement of partitions, and with connection for either aërial or underground mains.

Provision should also be made for local central stations and swithcboards.

### LETTER DROPS.

Letter drops should be located at convenient points on each floor, and if the building is extensive, a sub-Post Office should be centrally located, with pneumatic conduits for collecting the mail.

## MECHANICAL INSTALLATION.

As it is necessary, except in the tropics, to heat all our community buildings, and as steam is the most flexible vehicle for the purpose, since by its use we can reclaim and use approximately 70% of the heat units in the combustible, and by judicious installation and operation reduce the power required to a by-product—we may consider that steam is an essential.

### BOILERS.

Going back again to the Drexel building, put into commission November, 1888, and starting with the boilers:

These were four in number, internally fired "Galloway," with

the style of setting afterwards adopted. These boilers answered their purpose with economy, as operated, until the load demanded by sub-division of offices was so increased that not only were they run at a financial loss but their maximum capacity was exceeded. In 1903 these boilers were removed, and Edgemore Water Tube Boilers, with four times the capacity of the original installation were substituted.

I am advised that the coal saving realized during the first year of the new plant, over that for the last year of the old plant, amounted to over 35%, and by substituting buckwheat for pea coal a net saving was obtained of one-half of the cost, showing approximately the saving obtained by ample boiler capacity with maximum grate surface over a limited capacity with minimum grate surface.

In this conjunction the installation of not only ample but seemingly excessive boiler capacity is advised.

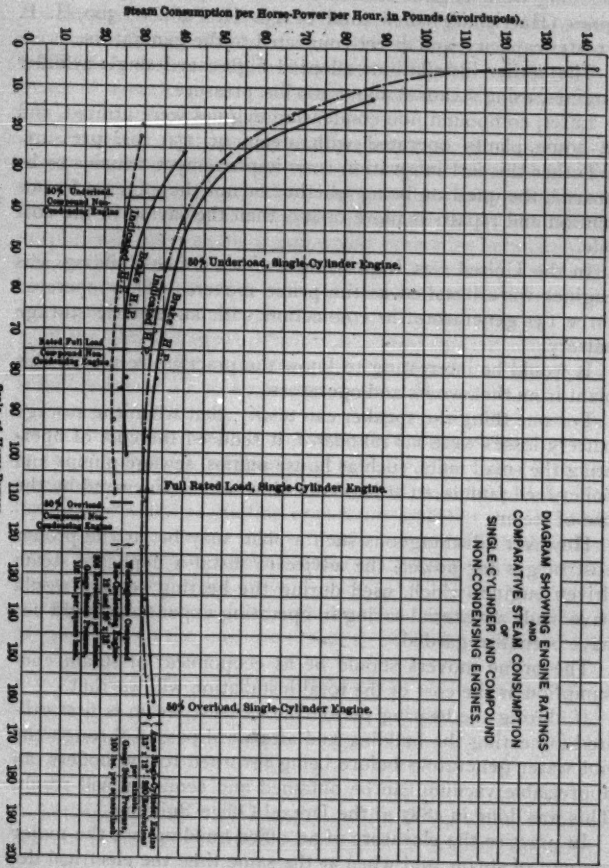
### PRIME MOVERS.

The original electrical installation in the Drexel Building included two horizontal simple Armington & Sims engines of fifty H. P. each and one 100 H. P., operated by 100 lbs. steam pressure, belt-connected to four Edison, compound, direct-current generators.

These engines were operated at their nominal load (one-quarter cut off, 100 lbs. pressure), until 1900, when generators of 50% greater capacity were substituted for the original generators and operated by them.

In this connection your attention to the steam consumption on the load diagrams showing that with a variable load (such as we have on an engine serving directly the lights and power), there is a decided advantage in proportioning the engine to drive the maximum at about one-half cut-off. The diagram shows, in a variation from 25% to 150% of the rated load of the engine at one-quarter cut-off, a variation of less than 10% above the point of minimum steam consumption.

Mr. Westinghouse appreciated these facts, for the market rating of the Westinghouse engine is at the maximum load and the lowest steam consumption or proper rating is at about 70% of the maximum load.


Steam Consumption per Horse-Power per Hour, in Pounds (avoirdupois).
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140
Scale of Horse-Powers.
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200
50% Underload, Compound Non-Condensing Engine
Rated Full Load, Compound Non-Condensing Engine
50% Overload, Compound Non-Condensing Engine
50% Underload, Single-Cylinder Engine.
Full Rated Load, Single-Cylinder Engine.
50% Overload, Single-Cylinder Engine.
DIAGRAM SHOWING ENGINE RATINGS AND COMPARATIVE STEAM CONSUMPTION OF SINGLE-CYLINDER AND COMPOUND NON-CONDENSING ENGINES.

In 1903, after a run of fifteen years, the engines at the Drexel Building were as good as new and were replaced by other engines (Harrisburg) of a total of 450 H. P., *i. e.*, 300 H. P. greater capacity, and direct-connected to the generators.

The earlier installations adopted high-speed single-cylinder engines, using steam at about 100 lbs. pressure.

Later, compound non-condensing engines were utilized, and in some plants operated with steam at 150 lbs. pressure. Whether this last innovation is an improvement remains to be proved, the question being whether or not the expense for attention and repairs is more or less than the saving in the coal pile.

In the United Gas Improvement Co.'s Office Building, gas engines were installed as the prime movers. They operated three (3) generators, in connection with an electric storage battery.

It would be interesting to know the practical results of this plant from the owners and operators.

For one thing the speaker can testify, that when the storage battery losses were *not considered*, it reduced the cost of operating the small units, such as house pumps, sewage pumps and boiler-feed pumps, to at least one-third of that incurred by the use of steam.

However advantageous such a plant may be, at the proper cost of gas for power, the advice to instal a duplicate steam driven engine (which, used during the heating season, would have made a material saving in operating expenses) should not have been disregarded.

The prime movers should be as economical of steam consumption as the cost of the total installation will warrant.

If, during the heating period the exhaust steam is first utilized in heating the building and afterward passed through the hot water generators before being returned to the boilers, an appreciable vacuum can be obtained and economy will result. This was done in 1887 at the Drexel Office Building.

In practice the elevators of an office building use the major amount of steam, and when at the same time the electrical demands are at the maximum, it often happens that there is more steam used for power than is required for heating, and the resultant exhaust is wasted.

It has been sought to prevent this loss by operating the electric generators beyond the immediate demand and storing the surplus to be used when the exhaust from the elevator service would be sufficient to heat the building.

The first cost of such an installation, together with the expense of operating and maintenance, however, has proved this method to be uneconomical.

If, however, the spare engine, always provided in a well-designed plant, be direct-connected to an air compressor, and the air stored; the air could be used as a substitute for steam in the engines driving the electric generator or in air motors, during such times as the steam would otherwise be wasted.

The exhaust from the engines using compressed air and the air motors can be used to refrigerate the water for drinking as well as to cool the air supplied in the ventilating system.

In the past the great difficulty has been that, in using compressed air, ice forms in the valve chest and in the exhaust, from condensation of the moisture in the free air.

The speaker has overcome this difficulty, at merely the cost of handling materials. It will, therefore, be seen that the cost of the apparatus for the storage of power is reduced to the minimum, *i. e.*, the cost of steel storage tanks with their incidental valves and regulating apparatus, and that the loss from the cost of production is the fraction of an additional power unit. The expense of compression can be charged against the additional useful result.

The speaker would fully endorse the now common practice of operating all the small power units with electricity.

## FIRE PROTECTION.

Although it is presupposed that the buildings are fireproof, yet the trimmings, the furniture and the documentary contents are either inflammable or may be injured by fire or its antidotes.

It is therefore necessary that the antidotes be administered so judiciously that "the punishment will fit the crime," and by preventive measures reduce the crime to an insignificant misdemeanor.

As heretofore noted, at the Drexel Building, in 1886, there was designed and, in 1888, put into practice all the apparatus then known to the art.

In the Office Building of the United Gas Improvement Co. (1898), having the then advantage of the electric storage battery, an electrically-driven pump was installed by which water at a pressure of over 100 lbs. per square inch could be turned into the fire protection service in less than two minutes of the receipt of an alarm. In addition to the nozzles and hose on each floor, nozzles and hose were located on the roof.

These high-pressure water-service pipes for fire protection were, in addition to the storage-water supply in the attic, also provided with an inlet nozzle in the street to which the Municipal Fire Protection Service could be attached.

### WATER SUPPLY.

As the municipal water supply is rarely under sufficient pressure to supply our tall buildings, it is necessary to install a water pumping plant and to insure economy in operation and comfort in administration, ample reservoir capacity at such elevation as will serve the building by gravity.

Multiple-plunger pumps, driven by direct-connected motors, are best adapted for this service.

The water used for sewage disposal makes the greatest demand upon this service, and can generally be obtained from the ground under the site of the building, from driven wells at no great depth.

By the utilization of this water (which, although generally, in large cities, is unfit for drinking, is perfectly clear and useful as a sewage carrier), the water rents can be reduced to a minimum.

This water, being quite cool, can also be utilized in refrigerating the air for ventilation by passing it, before delivering it to the storage tank, through the coils used in winter for tempering the air supplied for ventilation.

### HOT WATER SUPPLY.

If my memory serves me correctly, the supply of hot water to individual offices was first installed in the Professional Building.

This water was distributed on the double supply system, with the result that water at 200° Fahr. was immediately on tap at instant demand.

## ELEVATOR SERVICE.

The modern passenger elevator service, suitable for office buildings can be traced to 1880, when high-speed hydraulic elevators were installed in the Pennsylvania Railroad Terminal Station, and elevators with a maximum speed of 700 feet per minute were successfully operated. So that in 1886-87, when the Drexel Building was designed, this problem had been solved.

From time to time improvements have been made in the apparatus as regards safety, comfort and economical operation.

Prior to 1887, the simple duplex steam-driven pump, was used to operate the hydraulic elevators. The apparatus in the Drexel Building was furnished with compound duplex pumps. Since that time, high-duty compound rotary pumps have been introduced.

Electrically-driven elevators have also been extensively introduced, initiated, I think, by Mr. Frank J. Sprague.

These electrical machines are subdivided into the drum type and what is known as the Sprague screw type. An electrically-driven pump was found, in some instances, advantageous to operate hydraulic machines.

Water and electricity superseded the old-style steam-driven drum machines and made possible the nice adjustments, in running, so necessary in the office building.

Many varieties of the hydraulic apparatus, more or less perfect and adapted to the different conditions obtaining in the various buildings, were designed from time to time. At first, the vertical and horizontal cylinder machines, pulling or pushing the piston which connected with the hoisting ropes, over multiplying sheaves, were presented to the designing engineer.

About 1898, the direct hydraulic-plunger machine (which had previously been installed for lifts not exceeding fifty feet), was adapted for use in high buildings, and, for lifts not exceeding 200 feet, have become quite popular.

The Sprague electric screw machine, after the general design of the hydraulic cylinder apparatus, with the endless screw and nut operating the multiplying gear of the rope hoist, was invented, and put on the market about 1896.

Such elevators were installed in the U. G. I. Office Building

and are giving satisfaction, both as to the consumption of power and for wear and tear. The screws, so much feared, have shown at the U. G. I. Co., an average life of four years.

The drum electric machines cannot be classed as applicable to the co-called high building, as at present understood.

In safety appliances, some improvements have been made in automatic apparatus. These improvements, together with the Cruikshank device (first utilized about 1900 to 1901) have practically supplanted the one-time supposed indispensable air-cushion.

Pneumatic devices for closing hatch doors, electric signals, and a host of minor conveniences have been invented and utilized in the past ten to fifteen years,—some wise, some otherwise.

The elevator apparatus has now reached such perfection, that the percentage of accident is less than is recorded for any other method of transportation, and engineers are building speed elevators for office buildings of 500 feet and over.

## ELECTRICAL SERVICE.

The principal uses of electricity in the Community Building are for communication, illumination and power.

In the year 1845, Professor Henry, of the Smithsonian Institute, illuminated his home with direct electric current, from a static battery, passing through a filament in vacuum. From this we have the incandescent lamp of commerce, without which to-day we would be lost.

In 1870, Bulwer-Lytton wrote "The Coming Race," in which he described what we now have and that which is to come.

In 1876, John Wanamaker installed a Jablochkoff candle in front of the entrance to his Grand Depot—one of the first examples of commercial electric lighting.

The Jablochkoff candle was an arc lamp, served with high-tension dynamic electricity.

About 1881, simultaneously, or nearly so, Moses G. Farmer, Hiram Maxim and Thomas A. Edison, produced and placed in the market the commercial incandescent electric lamp served by dynamic electricity.

Office Building of the United Gas Improvement Company, Philadelphia.

These early lamps were run only in "series" and utilized current of about fifty volts pressure.

In 1884, or 1886, Mr. Edison invented and marketed a lamp which could be run in multiple and with current at a pressure of about 110 volts.

It was not, however, until 1898, when in Philadelphia, a plant was designed and installed by the speaker which successfully utilized incandescent lamps in multiple at an electrical pressure of 220 volts.

This innovation reduced the conductors to one-quarter that required by the 110 volt current and to one-eighth that required by the fifty volt lamp in multiple.

Philadelphia can therefore justly claim the credit for this advance as developed and perfected at the Office Building of the United Gas Improvement Co., for previously a noted New York engineer had unsuccessfully attempted to utilize this voltage in the R. G. Dun Building, and also in the Lorraine Hotel, New York City, and he says he "thought the wiring millenium was arriving," but he goes further and describes his troubles and states "that no one should adopt this voltage, etc., etc.*

## ELECTRIC GENERATORS.

The electric generators installed in the Drexel Building (1888) were four in number at forty k.w. each, belt driven from steam engines, direct current, bi-polar compound wound to compensate from 110 to 118 volts pressure.

They were of the first lot of compound wound machines made by the Edison Company. The earlier generators were either shunt or series wound, with, I think, one exception in the horizontal bi-polar, compound, dynamo made by the Sawyer-Mann Company.

One of these generators was installed as early as 1885 in the store of Hood, Bonbright & Co., Twelfth and Market Streets, Philadelphia. The regulation of this machine was perfect. I pulled the main switch with the generators running under full load and without observable change in the potential of the pilot lamp on the machine.

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*See Note A, and Transactions of Am. Soc. of Civil Engineers, Vol. xlviii, pp. 34, 56, 57 and 58.

The Edison bi-polar generators in the Drexel Building were operated until the year 1900, or about twelve years, when they were replaced by Westinghouse generators with a 50% greater capacity. If my recollection serves me, but one armature on the old machine was replaced, and at the end of the twelve years the apparatus was in excellent condition, and, except for the wear on the commutators, had all the outward appearance of youth.

The generators in the U. G. I. Office Building (1898) were multi-polar, direct connected to gas engines, all the other apparatus in the building driven by electricity from a storage battery, no steam-driven machinery being installed.

### ELECTRIC MOTORS.

The electric motors driving the ventilating fans in the Drexel Building were two-pole, of Sprague design and after nineteen years of continuous running, ten hours per day, during office hours, are still in service and excellent condition.

I will not attempt to further discuss this subject, the ramifications of the motor field for work and the variety and designs are so great that time would fail.

### ELECTRICAL DISTRIBUTION.

The distribution service board originally installed in the Drexel Building was a plug board. My recollections of this provoke a smile.

Subsequently the board was substituted by one of modern design.

The electrical distribution was so sub-divided as to give the engineer in his office complete and individual control in detail of the entire building.

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## NOTE A.*

### THE ELECTRICAL PLANT IN THE OFFICES OF THE UNITED GAS IMPROVEMENT COMPANY.

In sharp contrast with the electrical plant of the Drexel Building, the electrical plant of the office building of the United Gas Improvement Company, designed in 1898, utilized successfully direct current electricity at 220 volts, distributed on a two-wire system. This voltage had previously been attempted in New York. In criticizing the use of this voltage (1892), the following remarks were made:

"The usual practice is as the author says, to use a two-wire system at 110 to 120 volts," but he goes on to advocate the use of high-tension current at 220 volts. The speaker designed the R. G. Dun Building for a 220 volt current, and thought the wiring millenium was arriving.

"The reduction in the cost of copper was tempting, the lamps appeared to be of about the same price, and it seemed to be advantageous to distribute both the motor load and the electric lighting load on the same basis from a two-wire switchboard. There was trouble with the distribution boxes, however, because a fuse letting go at the bottom of it would burn out the whole line. The lamps were inefficient, and, although they are somewhat improved now, they are still not as efficient by nearly twenty per cent. as the lamps at 110 to 120 volts; nor do they have so long a life, on all of which grounds the speaker (Mr. Bolton) bases his opinion that no one should adopt the higher voltage without serious consideration.

"The 220 volt system was also installed in the Lorraine Hotel. The tenants, assuming that the system was about the same as they had usually dealt with elsewhere, attached hair-curling tongs, portable lamps, fans, and all kinds of electrical notions, the result being that the fuses were constantly blowing out, which kept the chief engineer busy most of his time repairing breaks and grounds."

The criticism was answered as follows:

"The experience noted with the 220 volt system is certainly very unsatisfactory; the writer would imagine that the critic would have such experience in a hotel. The trouble mentioned with reference to the distribution boxes has not come within the writer's experience, but, from what has been stated, the further adoption of this voltage should be carefully considered."

"The many advantages to be gained in using this voltage should not condemn it because first attempts may show defects of installation. In the writer's practice, and from inquiry among those since using this voltage in Philadelphia office buildings, the troubles complained of have not been experienced.

"The higher voltage requires better installation and greater care in construction, and the fuses in the junction boxes should be arranged so that if one should burn out, it will not burn out the others.

"The lamps for the 220 volt current have been much improved, and no doubt will be improved further, as the 110 volt lamps have been."

"The experience in Philadelphia, with the practical use of this voltage, has been so successful that its further adoption is warranted, and, in the writer's opinion, the millenium should not be regarded as impossible because of first failure."

Extracts Am. Soc. C. E., Vol. xviii, "Mechanical Installation of Office Buildings."

(To be concluded.)

## Mining and Metallurgical Section.

# The Petroleums of North America. A Comparison of the Character of Those of the Older and Newer Fields.*

By Clifford Richardson.

Among the native bitumens those are to be classified as petroleums which are liquid at ordinary temperatures. Such a classification includes the more rarely occurring naphthas and the heavier malthas, the latter dense liquids flowing only very slowly at ordinary temperatures and gradually grading into the solid bitumens.

Petroleum is very widely distributed over the continent of North America and the adjacent islands. It is found in Alaska, in the Provinces of British Columbia, Alberta, Athabasca, Assiniboia, Ontario, Quebec, New Brunswick, Nova Scotia and Cape Breton of the Dominion of Canada, and in especially large amounts in Lambton and Essex counties in Ontario. It is well distributed throughout the United States from the Atlantic to the Pacific Coasts, forming numerous fields known as the Appalachian, owing to the fact that it follows the trend of the Appalachian Mountains, and including the States of New York, Pennsylvania, West Virginia, South-eastern Ohio and parts of Kentucky and Tennessee; the Ohio-Indiana, the Kansas, including portions of the Indian and Oklahoma Territories; the Texas and Louisiana; the Colorado; the Wyoming; and, on the Pacific Coast, the California fields of the Central Valley and of the immediate cost in Santa Barbara, Ventura, Los Angeles and Orange Counties. Petroleum, although undeveloped as a commercial product, is known in Mexico along the coast of the Gulf of Mexico, and it occurs in several localities in the Island of Cuba.

### DEVELOPMENT OF PETROLEUM AS AN INDUSTRIAL PRODUCT IN NORTH AMERICA.

Although petroleum had been collected in small amounts for many years previously its production on an industrial scale may be said to date from the completion of the first well, which was

*Read by title.

sunk for the purpose of obtaining oil, at Titusville, Pa., in 1859.* In 1861, the petroleum obtained from this field exceed two million barrels, of forty-two gallons, the output gradually increasing in Pennsylvania and New York until, in 1882, it was more than thirty million barrels.† From that time on the production has varied in these States, reaching thirty-three million barrels in 1891, and then decreasing until, 1904, when only a little over twelve million barrels was the output.

The total output of the Pennsylvania and New York fields has, therefore, decreased markedly in the last ten years, but that of West Virginia and South-eastern Ohio, which may be regarded as part of the same field, since the source and character of the oil is much the same, has increased to such an extent, from 492,578 barrels in 1890 to 12,644,686 barrels in 1904, as to make the product of the entire Appalachian field at the present time nearly as large as it was some years ago, the total production in 1904 being 31,408,567 as compared to 36,295,433 barrels, the largest output, produced in 1900, its value being greater than that of any other field.

As early as 1862, crude petroleum was produced to a small extent in the Province of Ontario, Canada, the output increasing in subsequent years until it exceeded one million barrels in 1894. From that date it has fallen off until ten years later, 1904, it was something less than half a million barrels.

In 1885, the petroleum of the Ohio-Indiana field became a factor in the North American supply, reaching over six thousand barrels in that year, and increasing to 24,689,184 barrels in the two States in 1904, making this field the third in its output and second in value of its product. Within recent years the production of the State of Indiana has increased largely, while that of Ohio has fallen off considerably.

The existence of oil in California was known as far back as the seventh decade of the last century, attention having been drawn to it by the State Geologist in 1865. It did not become of industrial importance until many years later, the output not exceeding 100,000 barrels until 1882, and 1,000,000 barrels only

*Petroleum and Its Products, 10th Census, S. F. Peckham, 1880, p. 11.

†This and the following data in regard to production are from Mineral Resources, U. S. Geological Survey, Washington, D. C., 1881-1904.

in 1895. In 1904 it had reached the astonishing figure of 29,049,434 barrels, and the State ranked as first in the amount of petroleum which it produced and second as a field, although not first in the value of its product owing to its inferior character.

Colorado first figures as a producing State in any amount in 1887, with less than 100,000 barrels. Since that time the output has reached over 800,000 barrels, in 1892, and has fallen off, in 1904, to 501,763 barrels.

The petroleum industry of Kansas and the adjacent Territories is the development of the last few years. In 1900, less than 75,000 barrels were produced, while in 1904, more than five and a-half million barrels were obtained in that State and the adjacent Territories.

Texas, the second largest producing State in 1904 and the fourth as a field, turned out over half a million barrels in 1901, and in 1904 reached 22,241,413 barrels.

The output in barrels of the various fields, which have been mentioned and the percentage of the total product in the years 1899 and 1904 are given in the following table:*

PRODUCTION OF PETROLEUM IN THE UNITED STATES, 1899 AND 1904. BY FIELDS.

(Barrels of 42 Gallons.)

| | 1899. | | 1904. | |
|---|---|---|---|---|
| | Barrels. | Percentage. | Barrels. | Percentage. |
| Appalachian | 33,068,356 | 57.962 | 31,408,567 | 26.830 |
| Ohio and Indiana | 20,225,356 | 35.460 | 24,689,184 | 21.091 |
| California | 2,642,095 | 4.633 | 29,649,434 | 25.328 |
| Colorado | 390,278 | .640 | 501,763 | .429 |
| Kansas, Indian and Oklahoma Terri's. | 69,700* | .122 | 5,617,527 | 4.799 |
| Texas | 669.013 | 1.172 | 22,241,413 | 18.999 |
| Louisiana | ..... | ..... | 2,941,419† | 2.513 |
| Wyoming | 5,560 | .010 | 11,542 | .009 |
| Other | 492 | .001 | 2,572 | .002 |
| | 57,070,850‡ | 100.00 | 117,063,421 | 100.000 |

*Only from the Kansas field.

*Mineral Resources, U. S. Geol. Survey, 1904.

†In addition to this quantity, 3,670,000 barrels were produced in Louisiana and unsold at close of 1904.

‡In addition to this quantity 13,578 barrels were produced in Kentucky and Tennessee in 1899, for which, as none was sold or used, no value could be given.

RANK OF PETROLEUM-PRODUCING FIELDS, ACCORDING TO THE VALUE OF THE PRODUCT, IN 1904.

| Field. | Rank. | Percentage | Value. |
|---|---|---|---|
| Appalachian | 1 | 41.12 | $41,602,798 |
| Ohio and Indiana | 2 | 35.55 | 35,966,189 |
| California | 3 | 8.17 | 8,265,434 |
| Texas | 4 | 8.06 | 8,156,220 |
| Kansas, Indian and Oklahoma Territories | 5 | 5.39 | 5,447,622 |
| Louisiana | 6 | 1.06 | 1,068,605 |
| Colorado | 7 | .57 | 578,035 |
| Wyoming | 8 | .08 | 80,794 |
| Michigan and Missouri | 9 | | 4,769 |
| | | 100.00 | 101,170,466 |

It will be noted from the above table that there has been a considerable rearrangement, in five years, in the relative amount of petroleum produced in the different fields, while the total production has more than doubled in the same period. The paraffine oils, however, those from the Appalachian, Ohio-Indiana, Colorado and Kansas fields, still form more than one-half of the output.

The rank of the different States as producers and the percentage of production in 1904 was:

RANK OF PETROLEUM-PRODUCING STATES AND TERRITORIES ACCORDING TO PRODUCTION IN 1904.

| | Rank. | Percentage. | Barrels. |
|---|---|---|---|
| California | 1 | 25.33 | 29,649,434 |
| Texas | 2 | 19.00 | 22,241,413 |
| Ohio | 3 | 16.13 | 18,876,631 |
| West Virginia | 4 | 10.80 | 12,644,686 |
| Indiana | 5 | 9.69 | 11,339,124 |
| Pennsylvania | 6 | 9.65 | 11,300,792 |
| Kansas | 7 | 3.63 | 4,250,779 |
| Louisiana | 8 | 2.51 | 2,941,419 |
| Indian and Oklahoma Territories | 9 | 1.17 | 1,366,784 |
| Kentucky and Tennessee | 10 | .85 | 998,284 |
| New York | 11 | .80 | 938,234 |
| Colorado | 12 | .43 | 501,763 |
| Wyoming | 13 | .01 | 11,542 |
| Missouri | 14 | | 2,572 |
| Michigan | | | |
| | | 100.00 | 117,063,421 |

In value of production the States ranked as follows:

RANK OF PETROLEUM-PRODUCING STATES AND TERRITORIES ACCORDING TO THE VALUE OF THE PRODUCT, IN 1904.

| State. | Rank. | Percentage. | Value. |
|---|---|---|---|
| Ohio | 1 | 23.46 | $23,730,515 |
| West Virginia | 2 | 20.35 | 20,583,781 |
| Pennsylvania | 3 | 18.29 | 18,507,103 |
| Indiana | 4 | 12.09 | 12,235,674 |
| California | 5 | 8.17 | 8,265,434 |
| Texas | 6 | 8.06 | 8,156,220 |
| Kansas, Indian and Oklahoma Territories | 7 | 5.39 | 5,447,622 |
| New York | 8 | 1.51 | 1,526,976 |
| Louisiana | 9 | 1.06 | 1,068,605 |
| Kentucky and Tennessee | 10 | .97 | 984,938 |
| Colorado | 11 | .57 | 578,035 |
| Wyoming | 12 | .08 | 80,794 |
| Michigan and Missouri | 13 | .08 | 4,769 |
| | | 100.00 | $101,170,466 |

## CHARACTER OF THE PETROLEUMS OF NORTH AMERICA.

Petroleums may be differentiated by their physical characteristics and their proximate chemical composition. They are mixtures of several series of hydrocarbons and their derivatives, in variable proportions and usually several and rarely all of the different series.

The determination of the proximate composition of crude petroleums has been hitherto attempted almost exclusively by distillation and has, therefore, been confined to the separation of the more volatile components, although by means of distillation in vacuo hydrocarbons of very high boiling points, over 350° at 50 mm. pressure have been separated, but not as simple substances. More recently the writer has undertaken the study of the residuals left after such distillation, by means of solvents, with results of considerable interest.

The nature of the proximate constituents which have been referred to can be most readily demonstrated by consideration of the components of the oils from the various individual fields the production of which has been described.

APPALACHIAN FIELD.

The petroleums of the Appalachian field, which includes Western New York, Pennsylvania, West Virginia, South-eastern Ohio and Eastern Kentucky, are found in the strata of sand and pebble conglomerate from one hundred feet above the Pittsburg coal in the Carboniferous to nearly four thousand feet below it in the lower Devonian.* They consist fundamentally of one series of hydrocarbons, $C_nH_{2n-2}$, and are therefore, known as paraffine petroleums, although series less rich in hydrogen are present. The crude oil has in general a peculiar greenish color by reflected light and a deep reddish-brown color by transmitted light. In exceptional cases light colored oils are found, not darker than yellow or amber, which must have resulted from a selective filtration through strata which permit of the passage of only the less viscous hydrocarbons. The density of the average Appalachian petroleum, as it occurs in the pipe line runs to the refineries, is from .80 to .82, 45.0 to 40.7°B., a Pennsylvania pipe line oil examined by the writer in 1900 having a density of .8014, 44.7°B., but oil of as low a density as .771, 51.6°B., occurs in Washington County, Pennsylvania, higher than the average in the Berea grit in Ohio, and as high as .850, 33.7B., in West Virginia and Kentucky, some of the West Virginia oils being found to be extremely desirable lubricants after filtration and without distillation.

The examination of the crude petroleum of the Appalachian field has attracted the attention of numerous investigators, from the time of C. M. Warren, 1865, to the present. The results enable us to form a satisfactory idea of the proximate composition and character of this oil. Oils from different parts of the field have shown on examination in the writer's laboratory the following characteristics:

| | Ohio. Noble Co. | Pennsylvania. Pipe line. | Kentucky. Sunnyside. |
|---|---|---|---|
| Specific gravity, 25/25° | .8293 | .8014 | .8426 |
| Flash | Ord. | Ord. | Ord. |
| Viscosity, Pa. R. R. pipette | 42″ | 37″ | ..... |

*Mineral Resources, U. S. Geol. Survey, F. H. Oliphant, 1903, p. 650.

Volatility in Open Dish.

| | | | |
|---|---|---|---|
| 105°, 7 hours | 41.2 % | 47.3 % | 40.7 % |
| 160°, 7 hours | 43.0 | 58.0 | 44.5 |
| 200°, 7 hours | 59.0 | 68.0 | 58.0 |
| *To constant weight:* | | | |
| 105°, 42 hours | 48.7 | 58.7 | 70.6 |
| 160°, 70 hours | 61.0 | 71.8* | 73.8 |
| 200°, 49 hours | 75.0 | 84.0 | .... |

*49 hours.

Viscosity of Residue.

| | | | |
|---|---|---|---|
| 7 hours at 200° | Soft, | Soft. | Soft. |
| 49 hours at 200° | Brittle. | Brittle. | ..... |
| Penetration | Pitch. | Pitch. | ..... |

Distillation Engler's Flasks.

| | | | |
|---|---|---|---|
| Distillation begins | 85° | 80° | 67° |
| Below 150° | 23.0 % | 21.0 % | 19.0 % |
| 150-300° | 21.0 | 41.0 | 37.0 |
| 300-350° | 21.0 | 14.0 | 20.0 |
| 350-400° | 27.0 | 23.0 | 20.0 |
| Loss on acid treatment (150-300° fraction) | 5.0 | 1.8 | .... |
| Percentage of acid used | 2.5 | 2.0 | .... |

Specific Gravity and Refractive Index.

| | Sp.Gr. | Ref.Ind. | Sp.Gr. | Ref.Ind. | Sp.Gr. | Ref.Ind. |
|---|---|---|---|---|---|---|
| | Ohio. | | Pennsylvania. | | Kentucky. | |
| Below 150° | .7297 | 1.412 | .7188 | 1.415 | ..... | ..... |
| 150-300° | .8013 | 1.442 | .7984 | 1.437 | ..... | ..... |
| 300-350° | .8404 | 1.468 | .8338 | 1.462 | ..... | ..... |
| 350-400° | .8643 | 1.481 | Paraffine. | 1.470 | ..... | ..... |
| *After acid treatment:* | | | | | | |
| 150-300° | .8006 | 1.443 | .7791 | 1.438 | | |

Distillation in Vacuo.

| | | |
|---|---|---|
| *Atmosph. pressure:* | | |
| 120-170° | .7375 | 1.422 |
| *23 mm.* | | |
| 90-120° | .7796 | 1.438 |
| 120-150° | .8267 | 1.451 |
| 150-180° | .8305 | 1.464 |
| 180-230° | .8494 | 1.474 |
| 230-290° | .8746 | 1.489 |
| 290-320° | .8863 | 1.504 |

Distillation of a Pennsylvania petroleum on a larger scale, carried on by Mabery, give the following results:

| Fraction. | Per cent. |
|---|---|
| 50-150° | 21 |
| 150-200° | 11 |
| 200-250° | 11 |
| 250-300° | 13 |
| Over 300° | 42 |

The ultimate composition of the crude oil and of a residuum obtained by spontaneous evaporation of the oil in a current of air he found to be:*

| | Crude. | Residue 33.33 |
|---|---|---|
| Specific Gravity | .830 | .862 |
| Symbol | $C_nH_{2n}$ | $C_nH_{2n-2}$ |
| Carbon | 85.51 % | 86.16 % |
| Hydrogen | 14.18 | 13.69 |

From the preceding data it is apparent that the petroleums of the Appalachian field contain a high percentage of constituents which are volatile or distill at a comparatively low temperature and which are of a low density and suitable for the preparation of naphtha and illuminating oils.

A determination of the ultimate composition of these oils shows that they consist essentially of 85.5 to 86.0 per cent. of carbon, 14.2 to 13.5 per cent. of hydrogen and a few hundredths of one per cent. of sulphur and nitrogen.

The distillates of the crude petroleum have been examined with great care by Young, Mabery and others, with to the determination of their proximate composition. Mabery has found that the hydrocarbons of the $C_nH_{2n+2}$ series are present, with a few exceptions, from butane, boiling at -10°, to one of the formulæ $C_{35}H_{72}$, and that probably other solid paraffines of higher molecular weight are present the formulæ of which it is impossible to determine with our present methods. He also finds liquid saturated hydrocarbons of the $C_nH_{2n}$ series, from $C_{21}H_{42}$ to $C_{26}H_{52}$, and others of possibly higher molecular weight, while he has separated liquid saturated hydrocarbons of the $C_nH_{2n-2}$ series containing twenty-seven and twenty-eight atoms of carbon.†

Young has isolated from the lighter distillates of Pennsylva-

*Proc. Am. Acad. A. and Sci., 1904, *40*, 347.

†Proc. Am. Acad. A. and Sci., 1902, *37*, 595.

nia petroleum in a very considerable degree of purity the naphenes or monocyclic polymethylene hydrocarbons $C_nH_{2n}$, containing five, six and seven atoms of carbon, pentamethylene, methylpentamethylene, hexamethylene, dimethylpentamethylene and methylhexamethylene, corresponding to those found in Russian petroleum.

Both of the preceding investigators have found considerable amounts of aromatic hydrocarbons. Young finds benzol in the fraction boiling at about 65° and 66°, and toluol to a considerable extent in a higher fraction,* while other homologues have been detected by Mabery.

While unsaturated hydrocarbons are present in Pennsylvania petroleum, and are readily removed by strong sulphuric acid, there is, in the opinion of all modern investigators, no sufficient evidence that these hydrocarbons are members of the olefine series. Their actual structure has not yet been determined.

Sulphur and hydrogen derivatives of the hydrocarbons are present in but mere traces.

The following table gives the characteristics of the various saturated hydrocarbons of the $C_nH_{2n+2}$, $C_nH_{2n}$ and $C_nH_{2n-2}$ series, as described by Mabery and Young:

$C_nH_{2n+2}$ Hydrocarbons.

| Composition. | Specific Gravity. | Ref. Index. | Boil. Point. | Pressure. | Melt. Point. | |
|---|---|---|---|---|---|---|
| $C_4H_{10}$ Iso. | | | 0° | 760mm. | | Mabery. |
| $C_5H_{12}$ Nor. | .6250 25/25° | | 36.3 | " | | Young. |
| | .6261 0/4° | | | | | |
| | .6454 " | | | | | |
| " Iso. | .6392 " | | 27.95 | 711mm | | " |
| $C_6H_{14}$ Nor. | .6771 " | | 68.95 | " | | " |
| " Iso. | .6730 " | | 61.00 | " | | " |
| $C_7H_{16}$ Nor. | | | 98.40 | " | | " |
| " Iso. | .6969 0/4° | | 90.30 | " | | " |
| $C_8H_{18}$ Nor. | .7188 20/20° | | 125.00 | 760mm | | " |
| " Iso. | .7190 " | | 119.50 | " | | Mabery. |
| $C_9H_{20}$ Nor. | | | 151.00 | " | | " |
| $C_{10}H_{22}$ Nor. | .7479 " | | 163-164 | " | | " |
| " Iso. | .7467 " | | 173-174 | " | | " |
| $C_{11}H_{24}$ | .7581 " | | 196-197 | " | | " |
| $C_{12}H_{26}$ Nor. | .7676 " | | 214-216 | " | | " |
| $C_{13}H_{28}$ | .7834 " | 1.451 | 226 | " | | " |
| $C_{14}H_{30}$ | .7814 " | 1.436 | 236-238 | " | | " |
| $C_{15}H_{32}$ | .7896 " | 1.4413 | 256-257 | " | | " |
| $C_{16}H_{34}$ | .7911 " | 1.4413 | 274-275 | " | | " |
| $C_{17}H_{36}$ | .8000 " | 1.4435 | 288-289 | " | 10 | " |
| $C_{18}H_{38}$ | .8017 " | 1.440 | 300-301 | " | 20 | " |

*J. Chem. Soc., 1898, 73, 914 and 918.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| $C_{19}H_{40}$ | .8122 | " | 1.4522 | 210-212 | 50mm | 33-34 | Mabery. |
| $C_{21}H_{44}$ | | | | 230-231 | " | 40-41 | " |
| $C_{22}H_{46}$ | .7796 | 15° | | 240-242 | " | 44 | " |
| $C_{23}H_{48}$ | .7900 | 60 | | 258-261 | " | 45 | " |
| $C_{24}H_{50}$ | .7902 | " | | 272-274 | " | 48 | " |
| $C_{25}H_{52}$ | .7941 | " | | 280-282 | " | 53-54 | " |
| $C_{26}H_{54}$ | .7977 | " | | 292-294 | " | 58 | " |
| $C_{28}H_{58}$ | .7945 | 70 | | 310-312 | " | 60 | " |
| $C_{31}H_{64}$ | .7992 | " | | 328-330 | " | 66 | " |
| $C_{32}H_{66}$ | .8005 | 75 | | 342-345 | " | 68 | " |
| $C_{34}H_{70}$ | .8009 | 80 | | 366-368 | " | 72 | " |
| $C_{36}H_{72}$ | .80052 | " | | 380-384 | " | 76 | " |

Monocyclic Polymethylenes—$C_nH_{2n}$.

| Composition. | Specific Gravity. | Boil. Point. | Pressure. | |
|---|---|---|---|---|
| $C_5H_{10}$ Pentamethylene | .7000 0/4° | 50° | 760 mm. | Young. |
| $C_4H_{12}$ Methylpentamethylene | .7660 " | 72 | " | " |
| $C_6H_{12}$ Hexamethylene | .7722 " | 80.6 | " | " |
| $C_7H_{14}$ Dimethylpentamethylene | .7543 20/4° | 94 | " | " |
| $C_7H_{14}$ Methylhexamethylene | .7964 ' | 102 | " | " |

Hydrocarbons $C_nH_{2n}$.

| Composition. | Specific Gravity. | Refractive Index. | Boiling Point. | Pressure. | |
|---|---|---|---|---|---|
| $C_{21}H_{42}$ | .8424 20/20° | | | | |
| $C_{22}H_{44}$ | .8262 " | 1.454 | 240-242° | 50 mm. | Mabery. |
| $C_{23}H_{46}$ | .8569 " | 1.4714 | 258-260 | " " | " |
| $C_{24}H_{48}$ | .8598 | 1.4726 | 272-274 | " " | " |
| $C_{28}H_{52}$ | .8580 " | 1.4725 | 280-282 | " " | " |

Hydrocarbons $C_nH_{2n-2}$.

| | | | | | |
|---|---|---|---|---|---|
| $C_{27}H_{52}$ | .8688 20/20° | 1.4722 | 290-294° | 50 mm. | Mabery. |
| $C_{28}H_{54}$ | .8694 " | 1.4800 | 310-312 | " " | " |

It will be observed in the preceding tables that distillates from Pennsylvania petroleum have been obtained corresponding in composition to the presence of carbon atoms from four to thirty-five, with a few exceptions. While the lower distillates may consist of single hydrocarbons, it is impossible to believe that this is the case with the higher ones, owing to the large number of possible isomers. This, however, does not detract from the interest in the results obtained since they prove that hydrocarbons exist in petroleum of this derivation containing carbon atoms in these numbers combined with hydrogen in the proportions corresponding to the general formulæ $C_nH_{2n+2}$. All the members of this series containing fourteen atoms of carbon and above are solid paraffines, melting at from 10° to 60°, and Mabery has shown that these solid paraffines exist as such in the crude petroleum and are not formed as the result of

decomposition on heating, since he has isolated them from the crude oil without the aid of heat, by evaporation at ordinary temperature in a current of air, a fact which is not unexpected since they are found to separate naturally on the sucker rods of pumps in wells yielding petroleum in which the solid paraffines are present in large amounts.

The lower polymethylenes or napthenes, $C_nH_{2n}$, isolated by Young, are plainly monocyclic hydrocarbons. The higher distillates, like those which occur in Russian petroleum, corresponding in composition to the same general formulæ, and containing twenty-one atoms of carbon and over are associated with $C^nH_{2n+2}$ hydrocarbons containing the same number of carbon atoms or one or two less. They do not solidify at very low temperatures and are separated from the paraffines by freezing and filtration. From our knowledge of the hydrocarbons in asphaltic oils it would appear that they differ from them essentially, as they are much more stable, have a lower density, and, for the same refractive index, nearly double the molecular weight and a much higher boiling point:

| | Paraffine petroleum* | Trinidad asphalt† | California petroleum* | California petroleum† |
|---|---|---|---|---|
| Density | .8598 | .8690 | .8808 | .8654 |
| Refractive Index | 1.4726 | 1.4721 | 1.470 | 1.474 |
| Boiling Point | 272-274° | 170-180° | 175-180° | 178° |
| Pressure | 50 mm. | 30 mm. | 60 mm. | 30 mm. |
| Formulæ | $C_{21}H_{44}$ | $C_{21}H_{32}$ | $C_{21}H_{30}$ | ..... |

With the large number of carbon atoms which these hydrocarbons contain they must be either polycylic or contain an elaborate side chain. In the former case the hydrogen atoms should be less than twice the number of those of carbon and in the latter the hydrocarbons should be very unstable. We have no grounds, therefore, for any conclusions as to their structure, but it is evident that they belong to a series quite different in constitution from any that have been previously studied and that they are not identified with the asphaltic hydrocarbons.

The constitution of the hydrocarbons of twenty-seven and twenty-eight atoms of carbon, corresponding to the formula $C_nH_{2n-2}$ is equally difficult to explain. As this large number

*Mabery.
†Richardson.

of carbon atoms should correspond to the existence of at least three rings, this would not permit of the presence of hydrogen corresponding to the $C_nH_{2n-2}$ formula. The hydrocarbons of both of these series are saturated, that is to say, are not attacked by strong sulphuric acid, and consequently there is no possibility of the existence of double bonds.

The investigations, the results of which have been just outlined, have been confined to those proximate constituents of crude Pennsylvania petroleum which are obtainable by distillation in vacuo. The residues from such distillation are extremely dense substances which cannot be further distilled without cracking and must, therefore, be studied in quite a different way.

This has been done by the writer with the aid of solvents, treatment with acid, determination of their physical properties and the amount of fixed carbon which is left on ignition in the absence of air. The ultimate composition of such a residuum has been found by the writer to be:

| | |
|---|---|
| Carbon | 87.44 % |
| Hydrogen | 12.50 |
| Sulphur | .60 |
| | 100.54 |

It will be seen that, as compared with the crude oil, there is a smaller percentage of hydrogen and a larger one of sulphur in the residuum, which would naturally be expected. On treatment with ordinary and fuming sulphuric acid, however, the hydrocarbons which are unacted upon and which form 53.3 per cent. of the residue, have the ultimate composition of the $C_nH_{2n+2}$ series:

| | |
|---|---|
| Carbon | 84.74 % |
| Hydrogen | 15.30 |
| Sulphur | .21 |
| Nitrogen | .00 |
| | 100.25 |

More than one-half of the dense residuum from Pennsylvania petroleum consists of paraffine hydrocarbons, largely solid paraffines at ordinary temperature.

The further characteristics of such a residuum are as follows:

Physical Properties.

| | |
|---|---|
| Specific gravity, 25/25° | .9202 |
| Flash | 186° |

Chemical Characteristics.

| | |
|---|---|
| Loss 160°, 7 hours | 5.3 % |
| Character of residue | Soft. |
| Loss 200°, 7 hours (fresh sample) | 14.2 % |
| Character of residue | Soft. |
| Character of residue to constant weight | Brittle pitch. |
| Bitumen soluble in $CS_2$, air temperature | 99.8 % |
| Organic matter insoluble | .2 |
| Inorganic or mineral matter | .0 |
| | 100.0 |
| Bitumen insoluble in 88°B. naphtha, air temperature. Pitch | 4.3 % |
| Per cent. of soluble bitumen removed by $H_2SO_4$ | 21.9 |
| Per cent. of total bitumen as saturated hydrocarbons | 74.8 |
| Per cent. of solid paraffines | 11.0 % |
| Fixed carbon | 3.0 % |

It appears that the residue contains a certain amount of hydrocarbons or their derivatives which are volatile at 205° when exposed to this temperature in an open dish, and that if this exposure is continued for a certain length of time a brittle pitch is left. This pitch is no doubt formed by condensation due to the severe treatment to which the oil has been subjected and is not present as such in the crude petroleum.The residue carries a considerable percentage of solid paraffines which can be separated by the Holde method, as modified by the writer.* The amount, at least in industrial products, would depend upon the manner in which the distillation has been carried out. If a plentiful steam agitation is employed a part of the paraffine scale will be carried over into the distillate. The amount of fixed carbon obtained on ignition is very small, only three per-cent., a characteristic which differentiates the residuums from paraffine petroleums from those obtained from the asphaltic oils of California, as will appear later.

*J. Soc. Chem. Ind., 1902, *21*, 690.

It is also worthy of note that of the hydrocarbons present but from ten to twenty-two per cent. are in a form involving a double bond, since this is the amount removed from a naphtha solution of the residue on treatment with strong sulphuric acid.

A certain light is thrown, therefore, on the characteristics of the denser portion of the Appalachian petroleums by means of these determinations.

In rusumé, it appears from the preceding data, that the paraffine petroleums of the Appalachian field consist of small amounts of monocyclic, aromatic and polymethylene hydrocarbons, which have been separated in such a degree of purity as to be identified definitely; of minute traces of sulphur and nitrogen compounds and, predominatingly, of paraffine hydrocarbons from isobutane, $C_4H_{12}$ to $C_{35}H_{72}$, the members above 14 being solids at ordinary temperatures. Polycyclic hydrocarbons of the $C_nH_{2n}$ ceries are also present in very considerable amounts from $C_{21}$ to $C_{26}$, the constitution of which is not understood but which are quite different from the hydrocarbons of the same relation of carbon and hydrogen found in asphaltic oils, and have no relation to the ethylene or olefine series. Polycyclic hydrocarbons of the $C_nH_{2n-2}$ series are also present in the fractions boiling above 290°, at 50 mm. The latter two classes of hydrocarbons are worthy of careful study. They are saturated, in that they are not acted upon by strong sulphuric acid, and are all sharply differentiated from the hydrocarbons of the asphaltic petroleums of California by their physical properties. The opportunities for investigation in this direction are large but the problem is an extremely difficult one.

(To be concluded.)

# CHEMICAL SECTION.

## Note on the Examination of Maple Product—The Lead Value.*

By Albert P. Sy.

The usual determinations made in the examination of maple products are: moisture, specific gravity, total solids, ash, sucrose, reducing sugars (dextrose) and malic acid. Various investigators have made a special study of one or other of these constants. Jones, of the Vermont Agricultural Experiment Station, and Hortvet, of the Minnesota Dairy and Food Department, have studied in detail the ash of maple products. Not only have they established a figure for the minimum quantity of ash which should be found in a pure product, but they have determined the total alkalinity of the ash, alkalinity of the water soluble portion, alkalinity of the insoluble part, phenol phthalein alkalinity, methyl orange alkalinity, and also ratio of water soluble to insoluble.

Other investigators have paid more attention to the malic acid in maple products. The usual method for the quantitative determination of malic acid is the calcium chloride precipitation; the precipitated calcium malate is ignited to calcium carbonate and the latter determined by titration. Hortvet determines the bulk of a "lead sub-acetate precipitate" by a centrifugal method, and this gives an indication as to the amount of malic acid present, since sub-acetate of lead precipitates principally the malic acid. This precipitate is more or less copious in samples of known purity but only slight in adulterated samples, since the substances used for adulteration do not contain malic acid.

In the so-called Hill and Mosher method special stress is laid on the malic acid value, not only as to quantity but also as to the manner in which it is precipitated and how it filters. The malic acid is precipitated by neutral lead acetate, filtered, de-

*Read by title.

composed by hydrogen sulphide, and the malic acid in the filtrate determined by titration with deci-normal alkali. This process has given excellent satisfaction, but has the following objections: In some maple products, especially the adulterated ones, it is exceedingly difficult to make a satisfactory filtration of the precipitated lead sulphide, sometimes requiring days before the filtrate has passed through the filter; the filtrate is most always too dark or turbid to admit of a satisfactory titration and observation of the end reaction; and then there is the always objectionable use of hydrogen sulphide.

These objections I have overcome by modifying the process as follows: the first precipitate with the lead acetate, after washing, is transferred together with the filter to a beaker, nitric and hydrochloric acid are added and the beaker heated on a hot plate; finally add sulphuric acid, evaporate to fumes; if blackening occurs, add a little nitric acid, and then again to fumes of sulphuric acid; allow to cool, dilute, add alcohol, let stand for several hours, filter and determine lead as usual. Calculate to lead per 100 c.c. of syrup or equivalent of sugar.

It is hoped to present in the near future in this journal a detailed account of this method, as well as analytical data obtained on various maple products.

University of Buffalo, June 28, 1906.

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THE MASSACHUSETTS CIVIL SERVICE REFORM AUXILIARY offers free of expense, pamphlets on Civil Service Reform to Grammar Schools, High Schools, Normal Schools and Colleges willing to make these pamphlets the subject of a lesson in their Civics or American History Course. During the past five years over 125,000 of the pamphlets have been distributed to more than 1500 schools and colleges scattered throughout every State and Territory of the United States.

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## Section of Photography and Microscopy.

*(Stated Meeting, held Thursday, April 19, 1906.)*

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# On the Application of Farmer's Method of Reduction by Which the Shadows Are Preserved and Only the High Lights Reduced.

Mr. John Bartlett, Philad'a.

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The objection made, hitherto, to the so-called Farmer's solution for the reduction of too great intensity in the developed plate has been to the tendency of this agent to destroy the detail in the shadow parts of the negative, while acting upon the high lights, that is the thin portions suffered inordinately while the denser parts were reducing.

It was for this reason that the Lumière Bros. advocated the use of ammonium per-sulphate as a substitute on account of its more harmonious action on the film, that is attacking in preference the denser portions before acting on the shadows.

The ammonium per-sulphate undoubtedly does what is claimed for it, and in the majority of cases will be found to work effectively, but at times it is refractory, apparently not acting at all, even during a protracted manipulation, and on occasions acting injuriously upon the film by causing unevenness and stain or discoloration. Besides, its application requires considerable experience in manipulation to insure success, and also to preserve the plate from subsequent action which sometimes ruins the plate.

By a happy chance the writer was fortunate in discovering that the old stand-by, the ordinary so-called Farmer's solution, might be made under certain modifications to work as har-

moniously as the per-sulphate, that is to preserve the shadows while the high lights were reducing—with the further recommendation of its ease of manipulation and celerity of operation.

As everyone who works in photography knows, Farmer's solution is composed of a mixture of ferri-cyanide of potassium and hypo-sulphite of sodium. Saturated solution of ferri-cyanide potassium, 1 part, hypo-sulphite soda (1-5) 10 parts.

The novelty of my method is only in the constitution of the solution and the mode of its application. My attention was first called to the modification by observing how much more readily and harmoniously a plate reduces when the operation of reduction is performed immediately after the fixing of the plate and before any of the hypo in the film has been washed out. We are all liable, at times, to over-develop and to produce negatives which are harsh, dense and lacking in half-tones, and the fact is frequently patent to us on examination directly after removal from the fixing bath. And so it is the practice of many of us to reduce our obdurate plate then and there, before we place the plate in the washing tank. It was by noticing the better results so obtained that I was led to investigate the cause, and I found the reason to be that the unwashed plate had an excess of hypo in the film over the washed and dried plate reduced on the Farmer's solution made according to the old formula. That is, in order to get good results the hypo must greatly preponderate over the red prussiate of potassa or potassium ferri-cyanide. When the ferri-cyanide is in excess the shadows suffer the most. So the whole solution of the problem for harmonious reduction is to have an excess of hypo. Now, this might be told in a few words, and so I will briefly narrate my plan of manipulation, feeling assured that hereafter all who try the method will prefer the modified form of the Farmer's reducer to per-sulphate of ammonium.

On general principles it is best to reduce immediately after fixing, previous to washing, making the film acid with acetic or citric acid, and then placing it in a 5 per cent. solution of ferri-cyanide of potassium, lifting the plate up out of the reducer after a few minutes' immersion to note the effect, for the action must not be allowed to continue too long or the shadows will suffer.

When sufficiently reduced transfer immediately to the tap

and subject the plate to at least five minutes' washing; for although ferri-cyanide is a very soluble salt, it persists some time in the film, and if left to remain will go on acting and may thus carry the action too far.

When it is necessary to reduce a plate which has been thoroughly washed from hypo, the plan best to pursue is, first of all, to soak the film in a bath of weak acid, say 10 per cent. for five or ten minutes, and then to transfer it to a bath of hypo for another ten minutes, and finally to the action of a reducer composed of hypo and ferri-cyanide constituted as follows:

Saturated solution of hypo, 4 parts; saturated solution of ferri-cyanide, 1 part; made acid with citric or acetic acid sufficient to redden litmus paper.

This method of reduction also lends itself kindly to the manipulation of paper prints—bromide or solio—for entire or local reduction of too great intensity. The paper print must be thoroughly saturated with hypo, rinsed slightly off and then subjected to a diluted reducer constituted as above. That is, more water should be added, and for local reduction a tuft of cotton dipped in the solution may be employed upon the wet print.

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## ANNUAL REPORT OF RECLAMATION SERVICE.

The second edition of the Third Annual Report of the Reclamation Service, now published by the United States Geological Survey, is worthy of more special attention than was the first edition, because it is accompanied by a collection of fifty-nine maps, separately bound, which were prepared after the close of the field season as illustrations to the text. As the accompaniment is sometimes better than the song, so these maps may give to many a clearer idea of the reclamation work projected and now in progress than does the written record.

This report shows that examinations and surveys, as required by law, have been carried on throughout the arid regions, and that construction has been begun and has progressed rapidly wherever the surveys have demonstrated the practicability of a project. Taking into account the wide distribution of operations and the initiative and judgment which must be left to the engineers, it is believed that the results of the work are highly satisfactory.

This report is published for general distribution and may be obtained on request to the Director of Geological Survey. The usual quota is also supplied to members of Congress.

# Annual Reports of the Schools of Drawing, Machine Design and Naval Architecture for the Sessions of 1905-1906.

THE DRAWING SCHOOL.—The attendance in the several classes has been larger than last year. This is particularly true of the Architectural and Free Hand Classes, which have been very successful, and have done remarkably good, practical work. The increase in the mechanical classes has been small. Of course the location of the building and the absence of imposing and attractive accommodations has much to do with this, and it is greatly to be regretted that we are so poorly housed, and are so deficient in the material attractions of the modern school. As regards the actual instruction we remain pre-eminent, and for a logical, practical, up-to-date course, there is nothing superior. Every instructor is daily at work at what he is teaching. There is very little pedagogism but plenty of engineering, architecture and design. What we need is legacies, for it is impossible to make an institution of this kind efficient and progressive, and at the same time self-supporting.

WM. H. THORNE,
*Director.*

THE FOLLOWING STUDENTS HAVE DESERVED HONORABLE MENTION:

*In the Senior Mechanical Class.*

| | |
|---|---|
| Edward C. Pladder, | Clayton H. Robson, |
| Paul Saltzmann, | Elmer Cornell, |
| Frank H. Lobb, | William E. Press, |
| Frederick Fisher, | John H. Senior. |

*In the Intermediate Class.*

| | |
|---|---|
| Thomas P. Keeley, | William Underhoffer, |
| Joseph McFadden, | James T. Fennell. |
| Henry Schwemmer, | |

*In the Junior Class.*

| | |
|---|---|
| John A. Schaeffer, | Leonard Ware, |
| Howard G. Balz, | Alongo C. Love, |
| Horace Jackson, | Edward Jackway. |

*In the Architectural Class.*

| | |
|---|---|
| Charles Sticker, | Benjamin Batten, |
| William R. Rice, | William C. Klein, Jr., |
| Harry Morse, | Daniel Henon. |

*In the Free Hand Class.*

| | |
|---|---|
| Joseph Hadik, | Joseph McCarthy, |
| Valentine J. Huegel, | Paul Baer. |

James McDonald,
Joseph Kircher,
Edward Wilson, Jr.,
William Danks,
Joseph M. Lenoir,
George G. Gilson,
Francis A. Chiffelle,
James C. Norris.

THE SCHOOL OF MACHINE DESIGN.—We are pleased to report a substantial increase in the number of students attending our classes this year over those of last year. The interest of the students has been well sustained, especially in the classes in Strength of Materials and Machine Design, subjects which appeal to men more directly than mathematics, though no more essential to the engineer. The work done in the school of Machine Design should be of especial interest to draftsmen, and we find that the man who can make a neat and accurate drawing profits largely by our courses. Such being the case we see no reason why the men in the Drawing School should not graduate from there to our school; and we extend to the Drawing School graduating class of 1906 a cordial invitation to continue their good work by registering in our school next September.

We again express our gratitude to Professor Marburg for giving a series of lectures to our students on Stresses in Structures.

L. M. ARKLEY, *Director.*

The following students have successfully passed their examinations, their names being arranged in order of merit:

*Machine Design.*

Equal. Ruch, F. J., Fulmor, Wm. Jr., Kircheubel, Edward, Bonderenko, E.

*Mechanics.*

Megonigal, Wm. S.,
Smith, J. H., St. Phalle, F. de, Equal.
Kilmore, J. B., Rice, Wm. G., Equal.
Morison, R.,
Aroson, S. G., Schmid, John, Equal.
Ruch, H. J.,
Groben, H.

*Strength of Materials.*

St. Phalle, F. de,
Kilmore, J. B.,
Smith, J. H.,
Phillips, C. E.,
Megonigal, W. S.,
Aroson, S. G., Ruch, Herman, Morison, R., Equal.
Schmid, John.

*Trigonometry.*

Register, F., Wackenhut, J. H., Equal.
Myers, E. L.,
Hatfield, A.,
Hopping, E.

*Geometry.*

Hatfield, A.,
Wackenhut, J. H.,
Hopping, E., Myers, E. L., Register, F., Equal.

The Following Students are Awarded Scholarships from the B. H. Bartol Fund:

| | |
|---|---|
| Charles W. King, | David Bowers, |
| Charles T. Huegle, | William Markert. |

The Following Students, Having Attended a Full Course of Four Terms, with Satisfactory Results, are Awarded Certificates:

| | |
|---|---|
| E. LeRoy Hopping, | Thomas J. Delany, |
| Edward C. Pladder, | Warren G. Harbison, |
| John William Patterson, | William E. Press, |
| Alfred L. Carson, | Frank Butler, |
| Robert A. Feroe, | Joseph M. Schneider, |
| Edwin F. Bramin, | John H. Senior, |
| Frank H. Lobb, | George Chew, |
| Paul Saltzman, | Frank Dietz, |
| Joseph Mullen, Jr., | William R. Rice, |
| Rudolph Bergersrode, | Harry Morse, |
| Benjamin Batten, | J. Robert Lauer, |
| Paul Baer, | Frank Kerner. |

The Branch Drawing School, located at Kenderton Hall, Seventeenth and Venango Streets, has had a successful year, both as to the number of students enrolled and progress in the study of Mechanical Drawing, which is the only branch taught in this school. The removal of the school to its present location, where it has had increased space and facilities, and the good work accomplished by the students, have been the source of much encouragement to the directors and instructors. Manufacturing concerns in the neighborhood of the school have manifested a warm interest in its welfare and have given aid by recommending their young men to attend the school, and also by financial assistance in its maintenance.

H. R. Stacks,
*Director.*

The Following Students have Deserved Honorable Mention:

| | |
|---|---|
| Harry Pannepacker, | Albert Grant, |
| Frank McKeon, | Weston Mattis, |
| Vincent Casey, | Edward Merriam, |

H. M. Reynolds.

The Following, having Completed the Full Course of Four Terms, are Awarded Certificates:

| | |
|---|---|
| Albert Lehman, | Paul Kennedy, |
| William B. Neville, | Howard Blease, |
| George A. Peterson, | Elmer Costello, |
| Harry W. Waltz, Jr., | John P. Erdel, |
| Charles Bottke, | Harry Plant, |
| Nelson Eastburn, | George I. Bartleson, |
| James Wakefield, | Isaac Birch, |
| Kennard Vaughan, | Albert Digiacomo, |

*Algebra.*

| | | | |
|---|---|---|---|
| Brittain, W. F., | | Hasson, J. J., | |
| Schmid, W. L., | | Davis, W. A., | |
| Donahue, R., | | Frayne, L., | |
| Morrison, R. W., | } Equal. | Petri, A. H., | } Equal. |
| Gickler, A. M., | | Gauer, F., | |
| Goetlel, E., | | Gardener, E. C. | |

THE SCHOOL OF NAVAL ARCHITECTURE.—The present depression in shipbuilding and the unstable condition of the industry, resulting in a decreased demand for men of technical training, has been responsible for a reduction in the number of students taking the naval architecture course. The uncertainty as to the future of shipbuilding in this country has had its effect in making young men somewhat reluctant about adopting naval architecture as a profession and has resulted in a marked diminution in the number of students preparing for this vocation, not only in Franklin Institute, but in nearly every technical school in the country.

The enrollment at the beginning of the school year, while below the average, was satisfactory, but adverse conditions which affected the students personally produced a considerable decrease in the attendance. Those who enrolled at the beginning of the Spring term have established a record for attendance that is remarkable. Scarcely an absence has been recorded against any of them and the majority have attended every session.

Considering that the students have been severely handicapped by a lack of the usual appliances of a drawing office, they have shown excellent progress. The presentation of abstract theories has been excluded as being considered of no practical value under the circumstances, but an attempt has been made to supply a large amount of information that would be of benefit in the drawing room or in making an elementary practice of the profession. It has been thought best to give most of the instruction by means of lectures supplemented by the use of text-books. This affords a better opportunity to consider those particular phases of the subject that appear important and essential and permits the special consideration of matters that are often omitted from text-books. An encouraging feature has been the earnestness of purpose and the evident desire to learn which all the members of the class have manifested.

The course is now well organized and arranged to suit the needs of the particular class of students which it is designed to serve, and it is hoped that a revival of shipbuilding will result in larger classes next year.

The following students have completed the full four-term course and are entitled to certificates:

Alfred A. Eichler, James J. Holland.

MELVILLE H. KEIL, *Director.*

# Franklin Institute.

*(Proceedings of the stated meeting held Wednesday, June 20, 1906.)*

President JOHN BIRKINBINE in the chair.

Present, members and visitors. Additions to membership since last report, eleven.

The announcement was made of the presentation to the Institute, by Mrs. T. S. C. Sulley Darling, and Messrs. Burnham, Williams & Co., of a handsome portrait in oil, of the late Mathias W. Baldwin, founder of the Baldwin Locomotive Works, and active in the management of the Institute in its early days.

After some appropriate remarks by the President, Prof. Lewis M. Haupt, duly seconded, moved a vote of thanks to the donors, which was unanimously adopted.

Prof. Haupt then presented a communication on what he termed "Aneverending Problem," which related to the subject of the interoceanic canal across the American Isthmus. Discussed by Dr. Edward Goldsmith, Mr. L. E. Levy, the President and the speaker.

The meeting passed a vote of thanks to the speaker of the evening, and the session was adjourned.

LEWIS E. LEVY, *Sec'y pro tem.*